77 00524

SAN FRANCISCO BAY AREA

IN-DEPTH STUDY

INSTITUTE OF GOVERNMENTAL
STUDIES LIBRARY
JAN 25 1977
UNIVERSITY OF CALIFORNIA

VESSELS AND PORT FACILITIES ANALYSIS

PORT FACILITIES CAPABILITY STUDY

JANUARY 1976

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

TABLE OF CONTENTS (Cont'd)

Paragraph	Subject	Page
27	CAPACITY CRITERIA	17
	a. Ship Load	17
	b. Cargo Transfer Rates	18
	c. Transit Shed Storage	19
	d. Open Storage	20
	e. Methodology	20
28	SAMPLE CALCULATION	21
	a. Ship Capacity	21
	b. Storage Capacity	22
	c. Berth Capacity	22
	CONTAINER CARGO FACILITIES	
29	INTRODUCTION	22
30	TERMINAL CHARACTERISTICS	23
	a. Ship Berth	23
	b. Containers	23
	c. Marshaling Yard	23
	d. Container Handling Equipment	24
	e. Container Freight Station (CFS)	25
31	FACILITY OPERATION	26
	a. Chassis Storage	26
	b. Straddle Carrier	27
	c. Transtainer	27
32	LASH SHIP TERMINAL	28
36	PORT OPERATING ARRANGEMENTS	29
37	CAPACITY CRITERIA	30
	a. Shipload	30
	b. Crane Capacity	31
	c. Land Requirements	33
	d. LASH Terminals	37
	e. Methodology	37

TABLE OF CONTENTS (Cont'd)

Paragraph	Subject	Page
38	SAMPLE CALCULATION	38
	a. Crane Capacity	38
	b. Yard Capacity	39
	c. Berth Capacity	39
	DRY BULK TERMINALS	
39	INTRODUCTION	39
40	TERMINAL CHARACTERISTICS	40
	a. Storage Facilities	40
	b. Material-Handling Equipment	41
41	FACILITY OPERATION	41
42	CAPACITY CRITERIA	42
	LIQUID BULK TERMINALS	
43	INTRODUCTION	43
44	TERMINAL CHARACTERISTICS	44
45	CAPACITY CRITERIA	45
	EXISTING FACILITY CAPABILITY	
46	INTRODUCTION	46
47	PORT FACILITIES AT SAN FRANCISCO	47
51	PORT FACILITIES AT REDWOOD CITY	49
55	PORT FACILITIES AT OAKLAND	50
58	PORT FACILITIES AT ALAMEDA	52
60	PORT FACILITIES AT RICHMOND	53
64	PORT FACILITIES ON SAN PABLO BAY, CARQUINEZ AND MARE ISLAND STRAITS	55

TABLE OF CONTENTS (Cont'd)

Paragraph	Subject	Page
68	PORT FACILITIES ON THE WESTERN SACRAMENTO-SAN JOAQUIN DELTA	57
70	PORT FACILITIES AT SACRAMENTO	58
75	PORT FACILITIES AT STOCKTON	60
79	SUMMARY	62
81	DISCUSSION	63

LIST OF PLATES

No.	Title
1	SAN FRANCISCO BAY REGION
2	PORT FACILITIES AT SAN FRANCISCO, CALIFORNIA
3	PORT FACILITIES AT REDWOOD CITY, CALIFORNIA
4	PORT FACILITIES AT OAKLAND AND ALAMEDA, CALIFORNIA
5	PORT FACILITIES AT RICHMOND, CALIFORNIA
6	PORT FACILTIIES ON SAN PABLO BAY, CARQUINEZ AND MARE ISLAND STRAITS, CALIFORNIA
7	PORT FACILITIES ON THE WESTERN SACRAMENTO-SAN JOAQUIN DELTA
8	PORT FACILITIES AT SACRAMENTO, CALIFORNIA
9	PORT FACILITIES AT STOCKTON, CALIFORNIA

LIST OF APPENDICES

APPENDIX-A	PORT CAPACITY CRITERIA
APPENDIX-B	TABLES
APPENDIX-C	BIBLIOGRAPHY

INTRODUCTION

1. BACKGROUND

This report stems from the outline of work set forth in the "Revised Plan of Study of the San Francisco Bay Area In-Depth Study," dated January 1975. The purpose of this report is to identify the various types of cargo handling facilities that are currently being utilized as well as those that will be operational by 1980, and provide an estimate as to their throughput capabilities. Existing port areas subject to evaluation include San Francisco; Redwood City; Oakland; Alameda; Richmond; Sacramento; Stockton; waterfront facilities on San Pablo Bay, Carquinez and Mare Island Straits; and, the waterfront facilities on the Western Sacramento-San Joaquin Delta.

2. The "Port Facilities Capability Study" is one element of the "Vessels and Port Facilities Analysis," the purpose of which is to provide conceptual design and cost estimates of navigation development for use during the formulation and selection of alternative regional navigation systems to accommodate waterborne commerce in the San Francisco Bay Region.

3. An inventory of existing navigation and port facilities was completed in June 1973. The report, entitled Channels, Ports and Related Facilities Inventory, inventoried all navigation facilities in the Bay Region, including the Delta ports. Inventoried items included channels, berths, storage areas, equipment, surface transportation access, bridges, and pipelines. Having obtained the physical dimensions of the existing port facilities, the next step is to determine their throughput capabilities.

4. The capacity of a port may be thought of in terms of the rate at which goods pass through and ships are handled over some specified period of time, based on its physical assets - number of berths, number of cranes, etc. Given the size of the labor force, operational methods, etc., the physical plant and equipment can be evaluated in terms of a practical sustainable rate at which ships can be handled and cargoes moved through the port. It is thus possible to define a throughput capability based on the physical limitations of the facilities by assuming that the elements in the system are operated in an optimum manner.

5. The results of this study will be integrated with those of a concurrent study on projected commodity flow movements to determine whether there is a need for new facilities to accommodate projected future waterborne commerce movements.

6. METHODOLOGY

For the purposes of this report, cargoes carried by ships are classified into four groups, based on the type of facilities required to move waterborne commerce: general cargo, container/LASH cargo, dry bulk cargo, and liquid bulk cargo. General cargo includes items that are shipped in packaged form like bales, bags, barrels, and boxes. Also included are heavy lift goods such as automobiles, logs, lumber, and machinery. Based on the prevalent use of the Roll-On Roll-Off facilities in the study area, commodities transported in Ro/Ro vessels are typically classified as general cargo. Bulk cargo is defined as materials that are loose, unpackaged and can be poured or pumped freely into the ship's hold. This grouping includes dry materials such as

grain or ores, and liquid commodities such as petroleum products and chemicals. The container/LASH cargo category includes goods moved as a single unit in either 20 to 40 foot containers or aboard LASH (Lighter Aboard Ship) barges.

7. Defining the cargo handling capacity of a facility in terms of its physical components is only one measure of its true cargo handling ability. Operational characteristics of the individual terminals and the intermodal capacity of the railroad and highway systems to move the cargo into and out of the port complex must all be carefully analyzed before the true capacity of the port facilities in the San Francisco Bay Region can be determined.

8. The throughput capability, as determined in this report, is defined as the "practical maximum capacity" of the port facilities to move waterborne commerce. The criteria developed to evaluate this capability is based on both the physical components of the system and the operational factors associated with the port complex. Operational factors that would tend to reduce cargo throughput have been evaluated and incorporated into the criteria such that the cargo throughput is considered to be the maximum that can be economically achieved over the long-run.

9. Each of the public ports, and many of the private marine terminal operators, were surveyed to provide data relative to identifying the principle factors affecting the ability of a marine facility to move cargo from, to, and through the port complex. General criteria were established for the various modes of cargo handling facilities (i.e.,

container, general, liquid bulk, and dry bulk) as to their potential capability to move cargo. Specific methodology for each mode will be discussed in subsequent sections of this report. A summary of the criteria used in evaluating the cargo handling capability of Bay-Delta ports is provided in Appendix A to this report.

10. The general criteria were applied to the same facility types and adjusted for individual site conditions. In this manner each similar mode of operation in the study area was evaluated against the same set of standards. It was assumed that present methods of operation (e.g., container stacking versus containers on chassis) at individual sites would continue to be used.

SAN FRANCISCO BAY REGION

11. GENERAL DESCRIPTION

The area of investigation for this report consists of the San Francisco Bay Region counties of: Marin, Sonoma, Napa, Solano, Yolo, Sacramento, San Joaquin, Contra Costa, Alameda, Santa Clara, San Mateo, and San Francisco. The San Francisco Bay and Delta waterway system consists of the entrance at the Golden Gate, a series of connecting bays, two major rivers which have their confluence at the eastern arm of the Bay system and numerous interconnecting tidal waterways in the Delta area. The Bay system has an area of approximately 435 square miles and a shoreline of about 275 miles at mean sea level. Making up this system are four interconnected bays: South San Francisco Bay, Central San Francisco Bay, San Pablo Bay and Suisun Bay. The Delta area comprises a triangular-shaped area of about 115 square miles with the cities of

Sacramento and Stockton, and the confluence of the Sacramento and San Joaquin Rivers in the vicinity of Pittsburg forming the corners and the two rivers and the western foothills of the Sierra-Nevada forming the sides of the triangle. Within this triangular area are some 100 leveed and reclaimed agricultural tracts and about 600 miles of interconnected and meandering tidal waterways. Within this Bay-Delta waterway system is located seven ports and numerous private bulk cargo terminals all with channel access depths exceeding 30 feet mean lower low water (MLLW).

12. NAVIGATION OVERVIEW

The entrance to the Bay-Delta port complex is the mile-wide Golden Gate which is approximately 640 statute miles south of the mouth of the Columbia River and 420 miles north of Los Angeles. The entrance can be entered through one of three channels - the Bonita Channel, parallel to the coast north of Point Bonita; the main ship channel, which crosses the San Francisco Bar from a southwest direction; and the south channel, parallel to the coast south of Point Lobos. The San Francisco Bar is a submerged sandbar extending in an arc outside the Golden Gate at a distance of about five miles. The main ship channel through the Bar is 2,000 feet wide and 55 feet deep (MLLW). Inside the Bay, controlling depths in navigation channels are 35 feet deep (MLLW) in the Central Bay, San Pablo Bay and Suisun Bay. The South Bay Channel through San Bruno Shoal to Redwood City is 30 feet deep (MLLW). Both the Sacramento and Stockton Ship Channels are also 30 feet deep (MLLW). Deepening of the channels through Central Bay, San Pablo Bay and Suisun Bay to 45 feet (MLLW) and the Stockton Ship Channel to 35 feet (MLLW) is authorized as part of the San Francisco Bay to Stockton Project (John F. Baldwin Ship Channel).

13. Commercial ports within the Bay and Delta port complex are located at San Francisco, Redwood City, Oakland, Alameda, Richmond, Benicia, Sacramento and Stockton. The location of these ports is shown on Plate 1. Numerous private terminals and harbor facilities are located throughout the port complex, including the petroleum transfer docks and wharves along the south and east shores of San Pablo Bay, Mare Island Strait, Carquinez Strait and Suisun Bay. The commercial ports and numerous other public and private facilities of the Bay-Delta complex are served by approximately 160 miles of Federally-constructed and maintained navigation channels.

14. Port facilities in the San Francisco Bay Region offer a wide range of marine terminals specializing in the movement of specific commodities (liquid bulk cargo, dry bulk cargo, conventional break-bulk cargo, and containerized cargo).

a. Pier 96 at the Port of San Francisco is the world's first and largest LASH (Lighter Aboard Ship) terminal and is capable of handling all types of cargoes. Facilities are also available for containerized cargo and specific commodities, including grain, and automobiles.

b. The Port of Redwood City is the only deep-water port in South San Francisco Bay and is principally a bulk cargo port. The port is currently conducting a study to determine the type of cargo handling facilities it should develop to meet the future needs of its tributary areas.

c. The Port of Oakland is the largest container port on the Pacific Coast. Expanded container handling facilities at Oakland and

the increased containerization in international trade have resulted in recent dramatic increases in the volume of containerized cargo passing through Port of Oakland facilities.

d. The Port of Alameda is a public terminal which is privately operated. The port facilities are used for handling general cargo as well as bulk liquids, including vegetable oils, corn syrup, petrochemicals and petroleum products.

e. At the present time the Port of Richmond is essentially a bulk cargo facility, handling both liquid and dry bulk materials. There exists at the Port of Richmond the physical and locational attributes that are needed for a container port. Studies are being conducted to determine the feasibility of reaching that goal.

f. The Port of Sacramento is primarily an export port and inbound traffic is minor compared to outbound. Special facilities are available for handling rice and other grains. An increasing amount of the port's total tonnage is derived from the export of bulk woodchips. The port operates a container-barge service to the Bay Area ports for the handling of containerized cargoes.

g. With respect to deep-draft traffic, the Port of Stockton, like Sacramento, is primarily an export port for bulk commodities. A large part of the bulk commodities exported through the port originate outside the immediate trade area, including ores from Nevada and Utah and grains from the Midwest. LASH barges are used to some extent in the movement of cargo to and from the Port of San Francisco.

h. The remaining port facilities in the study area, including the privately-operated public port facility at Benicia, are located on San

Pablo Bay, Carquinez and Mare Island Straits, and on the western Sacramento-San Joaquin Delta. Cargoes handled at the Port of Benicia include automobiles, petroleum coke and phosphate rock. The other terminals are privately-owned and serve specific industries. Types of cargo handled include petroleum and petroleum products, chemicals, steel products, bulk sugar, ores, and gypsum rock.

GENERAL CAPACITY CRITERIA

15. GENERAL

The capability of a facility to move cargo through a port complex can be measured in many ways. The first step was to define the critical factors affecting the movement of cargo for each particular type of operational mode (e.g., breakbulk, container, etc.). Based on available information, general criteria were then established for the evaluation of these factors for determination of the practical maximum capacity for each facility in the study area. An analysis was made for each criterion and values chosen that are considered to be representative for the entire study area. Each terminal facility in the Bay-Delta region was evaluated against the established general criteria, with adjustments made to account for specific site conditions. The following general criteria are applicable to all modes of cargo handling. Criteria for specific cargo handling terminals are discussed in subsequent sections of the report.

16. BERTH OCCUPANCY

The time that a berth is occupied by a vessel is not a reliable indicator of the throughput capability of a marine terminal. Many

outside factors other than the cargo transfer operation may increase the total time that the berth is occupied. One such factor is whether or not a ship is fully loaded and unloaded at a single call. Most vessels calling at public terminal facilities handle cargo for many ports. They may pick up export cargo at the Port of Los Angeles, steam to San Francisco and discharge import cargo, and then move on to the Port of Seattle before returning to their foreign ports of call. The amount of cargo movement at each calling may be relatively small; however, the same amount of time is used for berthing and deberthing the vessel no matter how much cargo is handled. These smaller shipments of cargo tend to reduce the annual throughput capability of a facility, while at the same time increasing the total time that a berth cannot be actively engaged in the transfer of cargo. Other factors such as waiting for high tide, or the taking on of supplies all tend to increase the berth occupancy while the transfer of cargo is zero.

17. It is the wish of every steamship operator to have sufficient berthing space to accommodate every ship promptly on arrival, thereby eliminating costly waiting time. However, because of the random nature of ship arrivals the berths in a particular port may be vacant much of the time. Therefore, some compromise must be reached which will achieve the most economical transfer of cargo between ships and shore. Based on a study conducted by Walter C. Boyer, Deputy Administrator, Maryland Port Administration, it has been assumed that the service time for each individual berth, on the average, should not exceed four days out of every seven. Over a period of one year this results in a berth occupancy

factor of 57 percent. The actual service time for a particular berth may be, due to the nature of the terminal operation, much less. This service time is defined as that period of time in which the cargo is being loaded or discharged from a vessel. Three days out of every seven are consumed in non-cargo handling activities, including the maneuvering of vessels to and from the docks, delays due to equipment failure, and vessels waiting for tug assistance or high tide to approach terminals.

18. LABOR

Manpower requirements are considered to be adequate to meet any demands which might be placed on them. The breakbulk type of operation is the most labor intensive mode of cargo handling. The more mechanized operations require less but more highly trained personnel. It is assumed that with sufficient lead time the labor unions are able to provide the personnel necessary to operate each port facility in the study area.

19. It is assumed that as the amount of cargo through each facility increases, the terminal will be operated in such a manner as to take full advantage of the physical components of the system.

20. OTHER FACTORS

To simplify computations it is assumed that a linear relationship exists between the cargo transfer rate and the amount of cargo to be handled. This applies to both the use of longshoremen for general cargo and cranes for containers. Since both the berth service time and the transfer rate are constant, the total amount of cargo that can be transferred to and from a vessel is constant. Assuming an average vessel load (e.g. 400 containers per vessel call) determines only the number of vessel calls that can be accommodated, increasing or decreasing this

average ship load affects only the number of trips and not the total amount of cargo that can be moved through the facility.

21. Generally, constraints such as rail and truck capacities, equipment maintenance capacities and other such factors are considered to be secondary in nature and adequate to maintain the flow of cargo through the port complexes. A detailed analysis of these constraints is beyond the scope of this report, but will be studied at great length in the transportation assessment portion of the In-Depth Study. The exception to this is the grain terminals where the land-side transportation system is critical to the operation of the marine terminal and, as such, is considered in determining berth capacity.

GENERAL CARGO TERMINALS

22. INTRODUCTION

Although a great deal of attention has been given to the change from breakbulk to container operations, there will continue to be a need for the breakbulk-type operation in the foreign trade routes. Many foreign ports cannot berth the large container ships which are currently being used. In addition, many of the ports which are capable of berthing these ships do not have the necessary shore-based equipment to transfer the cargo and must therefore rely on conventional cargo handling methods. Some foreign steamship lines are operating profitably without the expense of new ships and large investments in containers and related land transportation vehicles and handling equipment. The result is that there will continue to be a demand for the use of the smaller general cargo ships.

23. TERMINAL CHARACTERISTICS

The major elements of a typical marine terminal engaged in the transfer of breakbulk cargoes are the following: ship berth space; shipside cargo handling space; transit shed; and open storage area. A brief discussion of these elements is presented in the following paragraphs.

a. Ship Berth Space. There are two basic types of berthing facilities in common use - the finger pier and the wharf. Piers are frequently referred to as "finger" piers because of the usual long and narrow configuration and their orientation at an angle with the shore. It is generally contiguous with the shore, but may not necessarily be so. Wharves are often termed "marginal" wharves because they are normally parallel to, and in contact with, the shoreline. The length of the berth is particularly important to the efficient operation of the facility. The American Association of Port Authorities recommends berth lengths for wharves in 750 foot multiples, with piers designed for 850 feet of docking length.

b. Shipside Cargo Handling Space. The apron is the space between the dock edge and the transit shed. It is utilized as the staging area for the transfer of cargo from the transit shed to the ship and vice versa. The width of the apron is based on the number of railroad and gantry crane tracks to be accommodated. For wharves, the apron widths for shipside handling of general cargo range from 30 feet with no railroad tracks, or only one track, to 39 feet with two tracks and 52 feet with three tracks. The presence of a gantry crane requires that an additional 10 feet be added to the above widths.

c. Transit Shed. The purpose of the transit shed is to store general cargo moved in waterborne commerce. The operation of a transit shed is entirely different from that of a warehouse. The transit shed requires a greater amount of aisle space for rapid handling of goods by mobile equipment. It provides a temporary storage for goods discharged from vessels and awaiting clearance through customs to points of distribution by means of truck or railroad carriers. It also receives cargo arriving by land transportation modes for marine shipment. Typical cargoes handled through the transit shed include those commodities which are suitable for shipment in bales, bags, barrels, or boxes.

d. Open Storage Area. Many oversized cargoes, including automobiles, lumber and logs, and heavy machinery are stored in areas without overhead protection. The amount of outside storage area required at any particular berth depends on the trade routes serviced by the terminal. Generalization as to the area requirements cannot be readily derived and are for the most part, commodity specific, and depend upon many local factors external to the cargo handling problem.

24. FACILITY OPERATION

The operation of unloading and loading a ship can be broken down into three groupings: shipboard activities; dockside activities; and transit shed activities. These are discussed in the following paragraphs.

a. Shipboard Activities. Movement into and out of the ship is accomplished by hoisting cargo through the deck hatches. The hoisting equipment is specialized to suit the requirements of the cargo, the ship, and the port facilities. This equipment is usually a part of the ship's gear, thus eliminating the need for dockside capability. This is the standard method for loading and unloading ships in the United States.

(1) Each hatch of a typical breakbulk vessel is equipped with a pair of cargo booms. During the loading and unloading process, one of these is stayed over the offshore edge of the hatch, the other overhanging the wharf. The two booms, each with its own fall and winch, are connected to a single hook. The booms are rigged so that by coordination of the two winches the cargo can be lifted off the dock and deposited in the square of the hatch on either the port or starboard side. Similarly, cargo can be removed from the hatch and deposited on the dock. The operator can maneuver the load vertically and horizontally at high speeds.

(2) The transfer of breakbulk cargo requires extensive use of longshoremen to perform the physical tasks required in loading and unloading ships' cargoes. This involves the movement of cargo from and to the vessel itself, sorting and piling of cargo on the dock, and direct transfer of cargo from truck or railroad car to vessel, and vice versa. With few exceptions the work is predominantly manual.

(3) For both the loading and unloading of a vessel, a "hold gang" is required. The "hold gang" is split into two teams, one working the starboard side of the ship and the other on the port side. When

loading, the hook delivers loads to each team. A four-wheeled hand truck, having no lifting capacity, is used to transport cargo between the point where the hook deposited or picked up cargo and the point of storage in the hold.

(4) The problems of space in the hold reduce the opportunity for mechanization. The usefulness of fork-lift trucks and other equipment is limited by odd-shaped spaces, low headroom, and the impossibility of leaving an adequate working aisle as the hold fills. When discharging, the hook is sometimes used to drag heavy cargo from the wings to the hatch square so that a direct lift can be made.

(5) The majority of general cargo is handled in lifts of five tons or less, generally considerably less. Heavy lifts, which may run up to 50 or 100 tons or more in the case of a locomotive or any other piece of heavy machinery, are handled either by a heavy lift shipboard boom or by wharfside equipment, which can be either fixed or mobile.

b. Dockside Activities. Movement of cargo on the dock is more extensively mechanized. The fork-lift truck is a versatile machine which can pick up unit loads or palletized loads off the apron, run them into the transit shed, and there stack them up to 16 or 18 feet high. The fork-lifts are considered to be efficient for horizontal travel up to about 150 feet. The most commonly used sizes have capacities of from two to three tons, although special use equipment can run up to a 20-ton capacity. Special handling devices can be attached so that the fork-lift truck can be used for moving unpalletized material, such as rolled paper or baled material.

c. Transit Shed Activities. A limited amount of material can be hoisted directly between the ship and highway trucks or railroad cars or the wharf. The greatest proportion of cargo moved over a berth usually requires handling into and out of the transit shed for sorting and temporary storage. Within the transit shed the cargo is sorted by destination; customs inspections are completed; counts are made; weights and volumes are measured; and repackaging is accomplished, as needed. Each of these, as well as other processes, require space in addition to the storage space required for the commodities. The efficient handling of breakbulk cargo requires the consolidation of small packages into suitable load units. This is achieved by stacking on pallets. The pallet is a double platform, separated a few inches by battens to permit the moving of the pallet by a fork-lift truck. The top platform supports the load and the bottom one provides a flat surface for stacking. Pallets are commonly made of wood with an eye at each corner for convenience in attaching slings. They come in a variety of sizes up to about 4 by 6 feet. Special sizes are made for special purposes. Goods unsuitable for palletization are handled in cargo nets.

25. ROLL-ON ROLL-OFF TERMINALS

A completely different type of operation is in use that provides some flexibility in the range of commodities that can be handled at a particular terminal. The system was initially developed for use in the handling of containers on chassis. The conventional container ship uses a lift-on arrangement for transfer of cargo, primarily by means of dock

based, gantry type cranes. The Roll-on Roll-off (Ro/Ro) operation differs in that tractors deliver the chassis onboard the ship, where they are detached from the tractor and secured to the deck, with the tractor returning to shore to pick up another trailer. The operation of loading and unloading goes on simultaneously.

26. The Roll-on Roll-off operation is versatile in being able to transport not only containers, but also heavy lift breakbulk cargo such as construction and material handling equipment, pipe and steel in long lengths, large tanks, boats, automobiles, trucks, etc. Large pieces of machinery can be shipped pre-assembled and ready for installation, eliminating expensive on-site assembly costs. The Ro/Ro operation has a fast loading and unloading rate and does not require expensive shore cranes.

27. CAPACITY CRITERIA

The criteria developed for general cargo terminals are based primarily on discussions with the staff of the various ports and reflect their experience with this type of commodity movement. Data was collected from the ports and analyzed to provide the foundation for the selection of the values for each of the criteria. The specific values presented below for the various criteria represent averages for the entire study area and should not be assumed as representative for any one facility in particular.

a. Ship Load. An analysis was made of ships calling at Bay region ports and it was found that, on the average, from 100 to 18,000 short tons of cargo was transferred at each vessel call. For the purpose of

this study it is assumed that the average breakbulk ship loads and discharges 1,500 short tons of cargo each call, with 2,000 tons assumed for Roll-on Roll-off vessels. For vessels transporting logs or lumber, from 10,000 to 18,000 tons of cargo is assumed to move across the dock at each call.

b. Cargo Transfer Rates. The ability of the longshoremen to transfer cargo from and to the vessel is an important factor in the capacity determination. The transfer capability of a stevedore gang is based on a rate of 15 short tons per hour for regular breakbulk cargo and 25 short tons for steel products and similar commodities. On the assumption that transfer operations for a single vessel would use three stevedoring gangs per 8-hour shift, this would result in the movement of 360 and 600 short tons respectively of breakbulk and heavy lift cargoes per shift. Considering the large number of general cargo berths in the study area, and the labor intensive nature of this type of operation, it is assumed that there is a sufficient labor force available to work each of the ports if each berth is worked on the basis of 1-1/2 shifts or twelve hours per day. For this study it is assumed that there is a linear relationship between the amount of cargo to be handled and the rate of handling it. If more than 1,500 tons of cargo constitutes a particular ship load, then a proportionate amount of time would be required to transfer it, resulting in fewer vessels calls. On an annual basis, the total amount of cargo that can be handled remains constant, only the number of vessels moving that cargo varies.

c. Transit Shed Storage. The available storage space and the turnover in that space is another factor which must be considered. The capacity of a particular transit shed is determined generally by the expected volume of cargo to be handled. The space inside the shed allowed for shipping docks, trucks, access aisles, as well as the capability to efficiently handle cargo movements from ship-to-shore and vice versa, is commonly provided at 100 percent of the calculated cargo storage area. Thus, 50 percent of the actual floor area is allocated as direct storage space for cargo.

(1) Cargo is measured in a variety of ways. The weight ton is equal to a short ton (2,000 lbs.). The measured ton is equal to 40 cubic feet. For a particular cargo a revenue ton is considered to be greater of the two, which depends on the nature of the commodity being handled. For example, if the cargo weighs two short tons, but occupies a volume of 120 cubic feet, or three measured tons, the revenue tonnage would then equal three. To compensate for the mix of weight and volume oriented cargo that normally occurs at this type of facility, it is assumed that the actual floor loading of a transit shed, in pounds per square foot (p.s.f.), is equal to 50 percent of its rated structural loading capacity. For a transit shed floor with a rated structural capacity of 500 p.s.f., this results in a cargo capacity of 0.125 tons per square foot (t.s.f.).

(2) The time the cargo occupies the storage space affects the capacity of the facility. There is a free storage time provided for in the port operating tariff, which for outbound cargo, is ten days, and for inbound cargo, seven days.

Normally the commodities start building up in the port within the free time and most of the cargo is available when the ship arrives. Likewise, as soon as the ship unloads cargo, a portion is starting to head for its final destination, with most of the cargo dispersed prior to the end of the free period. Since not all of the cargo is distributed within the free period, it is assumed that, on an annual basis for all commodities handled through Bay Region ports, the transit shed experiences a turnover in the storage area of three times per month.

d. Open Storage. Area requirements for the storage of heavy lift cargoes such as automobiles, logs, and machinery are pretty much site specific and depend on the nature of the cargo handled. For automobile terminals additional area is required for the various servicing functions which are accomplished prior to delivery to the dealers. Each terminal is evaluated on the adequacy of its storage area in relationship to the throughput which could be achieved based on the expected pattern of ship arrivals. Normally it takes a minimum of ten days to survey the automobiles to determine theft and damage incurred during transit. For this reason it is assumed that a turnover of automobiles in the storage area would occur every twenty days or some eighteen times per year.

e. Methodology. The above criteria were evaluated and grouped into two standards of measurement; "ship capacity", and "storage capacity." The "ship capacity" standard considered the total annual tonnage that could be loaded and discharged from the ships arriving at the berth, taking into consideration the average amount of cargo handled per call, the scheduling of ship arrivals, and the assumed cargo transfer

rates. This estimate assumed unlimited storage. The "storage capacity" standard reflects the capability of the available transit shed storage space to handle the cargo, assuming the shed is used to its capacity at all times. A practical maximum capacity for each "standard" was calculated, with the lower of the two governing the cargo handling capability of the facility. In general, it was found that the "ship capacity" was the limiting factor for the breakbulk type cargo handling system.

28. SAMPLE CALCULATION

The intent of the following paragraphs is to present the application of the above discussed criteria in determining the cargo handling capability of a general cargo terminal. The methodology can be applied to both types of general cargo berths (i.e., finger piers and wharves) as well as to berths over which Roll-on Roll-off cargo is handled. Only the substitution of the appropriate values for each of the criteria is required.

a. Ship Capacity. For this sample calculation it is assumed that the amount of breakbulk cargo to be handled per vessel call is 1,500 short tons. With a cargo transfer rate of 45 short tons per hour (three gang crew), it would take 2.8 days (33.3 hours) to unload and load each vessel (1-1/2 shifts per day). With a service time of four days per week and a 50-week year, this would give a vessel calling record of 70 ships per berth per year, or a "ship capacity" of approximately 105,000 short tons of cargo per berth on an annual basis.

b. Storage Capacity. For a transit shed with a gross floor area of 80,000 square feet, and a floor loading rate of 500 p.s.f., approximately 40,000 square feet would be loaded to a rate of 0.125 t.s.f. Thus, approximately 5,000 short tons of cargo could be stored in the shed at any one time. This cargo would occupy 50 percent of the actual floor area. The remaining floor space allows the forklift trucks to operate efficiently in sorting, stacking, and moving the cargo. With a turnover in storage of three times per month, a "storage capacity" of approximately 180,000 short tons per year could be expected.

c. Berth Capacity. In comparing the two standards of measurement it can be seen that, for this particular terminal, the limiting constraint on the handling of cargo is the "ship capacity." The capacity of the facility would then be taken as 105,000 short tons per year.

CONTAINER CARGO FACILITIES

29. INTRODUCTION

The past ten years have been a period of revolution in the shipping industry. The rapid rise in the shipment of cargo in containers is nothing less than phenomenal. The use of containers to ship cargo that was formerly handled by breakbulk methods presents many advantages. It permits increased vessel utilization and requires less labor to load and unload, while offering increased protection against loss and damage of cargo. A properly engineered container terminal can handle from three to five times the amount of cargo of a conventional breakbulk berth.

30. TERMINAL CHARACTERISTICS

The principle components that make up a typical container terminal are the ship berth, containers, the marshaling yard, container handling equipment, and the container freight station. Each of these are discussed in the following paragraphs.

a. Ship Berth. Because of the large land areas required, berths for container ships are generally of the continuous bulkhead or wharf type, rather than finger piers or the dolphin type construction. Continuous wharves permit a higher degree of container crane utilization as well as a high berth-occupancy factor. Container ships are larger than general cargo ships, requiring berths up to 1,200 feet long.

b. Containers. The industry has worked for many years on the problems involved in the design and standardization of shipping containers. For the most part the dimensions for freight containers which have been agreed on are in accordance with the standards of the International Standards Organization (ISO), which are for an 8 by 8-foot box in the following lengths: 5-, 7-, 10-, 20-, 30-, and 40-foot. The United States standard which is being voted on in the American National Standards Institute consists of the following standard lengths: 10-, 20-, 24-, 30-, 35-, and 40-foot lengths. "High-cube" containers with depths up to 9-1/2 feet have come in to use in recent years.

c. Marshaling Yard. There are two general types of marshaling yard operations. The first has all the containers stored one-high on a truck-trailer chassis. Thus, each container is completely accessible at all times. As the containers arrive, they are assigned locations in the yard and remain in this position until they are moved either to the ship

for loading or out of the yard for shipment by truck or rail to a final destination. This type of operation requires more land area than does the second system, for the same throughput capacity. With the second system, containers are block-stored two and three high. This system is less flexible in terms of access to the containers, but its use results in higher utilization of land area. In using this system it is necessary to determine the optimum amount of block-storage that can be utilized without delaying the loading and unloading of the ship and incurring excessive yard costs for rehandling containers. Each container port has some of each kind of marshaling area.

d. Container Handling Equipment.

(1) Container Cranes. Containers weighing up to five tons can be handled by conventional port equipment. Efficient handling of large containers requires special equipment. Dockside installation is generally preferred since it permits the crane to reach a considerable distance inland as well as over the ship. The crane wheel loads are supported on girders built integrally with the wharf slab. The crane tracks usually run the full length of a continuous berthing facility so that a single crane can operate at any one of the berths as required. Normally, two cranes working simultaneously will unload and load a containership. In some instances, as many as four cranes are used simultaneously on a single ship.

(2) Marshaling Yard Equipment. Movement of containers from the wharf to the marshaling area is accomplished by yard tractors for chassis-mounted containers and by means of straddle carriers or fork-lift trucks for the block-storage operation. A third piece of equipment used in container yard rehandling is the traveling gantry crane, on either rails or rubber tires. It can stack containers up to four-high on the ground and then pick them up and place them on a railroad flatcar or truck chassis. This piece of equipment is commonly known as a trans-tainer.

e. Container Freight Station (CFS). Ideally, full containers go directly from shippers to consignees. However, all shipments are not full container loads and less-than-container loads (LTCL) must be assembled and combined to create full container loads. The purpose of the container freight station is to provide covered storage for sorting goods and repacking the containers when a single box holds merchandise for several destinations. The building's general configuration resembles a typical truck terminal, basically designed to have delivery trucks arrive at one side of the building and the cargo moved from these trucks directly into waiting containers on the opposite side of the building, with a minimum flooring of cargo. Some CFS facilities are also provided with special rail docks, with railroad boxcars handled along with trucks on one side of the shed and containers on the other.

31. FACILITY OPERATION

There are a number of storage and retrieval systems and combinations of systems in use at present Bay Region ports. Of these, the most commonly used today are chassis storage, the straddle carrier, and the traveling gantry crane.

a. Chassis Storage. Inbound and outbound containers are stored in the marshaling yard on standard over-the-road chassis. Incoming containers are weighed, checked in, and dispatched to an assigned parking location in the yard. Then, the over-the-road tractor either picks up a container and chassis, and makes delivery to the consignee, or returns to its operations base empty. Special yard tractors haul all containers between the marshaling yard and the wharf. At the wharf, gantry cranes lift export containers off the chassis and onboard the ship, and remove import containers from the hold, and place them on the tractor driven chassis for the trip to the marshaling yard. Since the containers are stored one-high, this system requires more terminal storage than any other container storage handling system. This system provides 100 percent handling efficiency because, as every container is immediately available to a tractor unit, the total required handlings are productive handlings. This system does require more chassis than any other system.

b. Straddle Carrier. This system stores containers on the ground two or three-high by straddle carriers, which are special pieces of equipment that straddle the containers and carry them through the marshaling yard. As an export container arrives, it is received in the marshaling yard and is removed from its chassis with a straddle carrier. The container is then moved to its storage place on the ground or on top of another container. To be loaded on the ship, the straddle carrier loads the container on a yard tractor trailer for delivery to the dock where it is placed aboard ship. Import containers which are unloaded from the ship are carried to the marshaling yard by the tractor trailer and stacked with the use of the straddle carrier. When the containers are ready for delivery, the straddle carrier places them on an over-the-road tractor and chassis. Less area is required with this system since containers can be stored two or three-high, but the handling efficiency is reduced to 50 percent or less because of the necessity to move an upper container to reached a desired lower container. In practice, some containers will always be chassis-mounted, and this becomes a combination system.

c. Transtainer. This system utilitizes a traveling gantry crane to stack the containers up to four-high in the storage area. Similar to the straddle carrier, the containers are delivered to and from the cranes by tractor-chassis units. Although the transtainer can stack higher than the straddle carriers, and thus makes for a more, efficient utilization of the storage area, the handling efficiency is further reduced by the many nonproductive handlings required for retrival of containers.

32. LASH SHIP TERMINAL

Containerization was developed on the premise that one of the key elements to economy was to keep the ship moving, since no revenue was produced when it was moored at a berth. As an extension to the container system of handling cargo the Lighter Aboard Ship (LASH) concept evolved. The lighter is a fully enclosed barge that carries the cargo and serves the mother ship. The lighters can handle unitized or palletized cargo, containers, dry and liquid bulk, baled cargo, heavy lifts, as well as odd-sized lots. The lighters are 31 by 61 by 13 feet deep and are rated for 415 short tons of cargo.

33. The LASH terminal has been designed to reduce the LASH ship's "turn-around" time to a minimum. To accomplish this, many unique cargo handling systems and equipment features have been incorporated on both shipside and dockside. The entire facility is designed to operate on a continuous basis, the loaded lighters having been readied for transfer to the LASH ship when it arrives in port. To facilitate the short "turn-around" time the lighters which are either awaiting cargo or are loaded are stored in the Lighter Storage Basin.

34. Adjacent to the Lighter Storage Basin is the Lighter Freight Station which includes a cantilevered canopy over the water for all-weather loading. The loading of lighters is accomplished with telescoping-mast stacker cranes suspended from trolleys attached to the canopy. Each crane can pick up palletized cargo from the dock, trolley out over a lighter and lower the load into the lighter. Additional features of the terminal are a container yard and dockside gantry container cranes.

35. The LASH ship is self-contained and requires no shore cranes for cargo handling. The entire lighter with its cargo is lifted from the ship by an onboard 500-ton capacity crane and released in the water to be towed to the port's dock or inland points. To load the ship the procedure is reversed. One 30-ton container crane is also onboard for the loading and unloading of containers. The ship is capable of carrying solely containers or solely lighters. The normal configuration for a LASH vessel is to devote one-third of its volume to containers and two-thirds to lighters. This type of operation is ideally suited for shallow draft ports and relatively undeveloped areas of the world.

36. PORT OPERATING ARRANGEMENTS

A port may have a variety of leasing arrangements with its tenants. These include steamship lines, terminal operators or stevedores, and consortia of steamship lines. Although a berthing complex may be leased to a particular steamship company, it may in turn handle cargo from other lines through its terminal facilities. This is the case with Bay area ports. Out of a total of 17 container berths which are currently operational, five berths are used exclusively for the handling of the lessee's cargo. One berth is not being used at the present time. The remaining eleven berths are designated either as public container terminals or are operated by steamship lines or terminal operators, handling cargo for more than one company. In the case of a terminal operated for a consortium of steamship lines, the operational characteristics are much like those of a public container terminal, which is a less efficient operation

than a sole-user terminal. When more than one line uses a facility, there must be some degree of separation of the cargo in the container storage yard, which tends to reduce the overall efficiency of the operation. Also, the probability of a variety of container sizes may affect the operation of the storage area. For the most efficient utilization of space, stripes are painted on the ground to indicate the positions that the containers will occupy. Since the yard is usually marked for a specific size container, variations from this standard will usually result in the placement of fewer containers per unit area. All of these factors tend to reduce the throughput capability of the terminal.

37. CAPACITY CRITERIA

As previously mentioned in the discussion on general cargo terminals, assumptions were made as to the measurement of these constraints so that the estimates of cargo handling capability could be made. The criteria developed are based on statistics from both the ports and actual operating data gathered from various terminal operators.

a. Shipload. Based on an analysis of traffic through the container terminals located in the study area, it was found that, on the average, from 200 to 650 containers were loaded and discharged at each vessel call. The facilities operated as public container terminals were found to be in the lower end of the range, while those operated exclusively for a single shipping line fell in the upper end of the

scale. Public terminals provide cargo handling facilities for shipping lines which either do not have sufficient trade to economically justify operating a berth for its exclusive use, or do not have a regularly scheduled trade route and call only when they carry cargo for that specific port. This usually results in fewer containers handled at each port of call. Due to the nature of the container traffic through the San Francisco Bay ports, some 25 percent of the total traffic consists of empty containers. This is due primarily to the fact that approximately 67 percent of the loaded containers through the ports are outbound. Thus the empties are returned as part of the inbound traffic.

b. Crane Capacity. Existing shore-based container cranes have a rated cycling time of approximately three to four minutes. Within this time, one container is removed from the ship and a second container placed aboard. Therefore, under ideal conditions such a crane could handle about 25 containers per hour. Under operating conditions, containers must be moved around for load adjustments, or to permit searching out particular containers. Based on actual operational data, it is assumed that full container cranes can operate at a sustained rate of from 16 to 21 container movements per hour. The more efficient single-user terminals operate in the upper end of the range, while the multiple-user terminals operate in the lower end.

(1) Seventeen containers per hour is assumed for those multiple-user terminals operated by a steamship line, while the public container terminal cranes are rated at 16 containers per hour. For chassis-mounted

container cranes a rate of 15 containers per hour is assumed. For the purposes of this study the cycling time of the crane is not affected by the size of the container being handled, so there is no difference between a 20-foot or a 40-foot container with respect to the operation of the crane.

(2) For a single-user terminal there is generally a highly coordinated effort between the operation of the container storage area and the operation of the crane during the loading and unloading of a ship. With this type of operation it is possible to actually load and unload simultaneously, thus achieving the most efficient use of the terminal. In a multi-user terminal, in which a great variety of situations might occur, the overall efficiency tends to be less. In general, the total number of containers handled per ship call is fewer and the movement of the containers in and out of the storage area is less coordinated. These factors tend to lower the transfer capacity of the cranes. In the single-user terminal most of the boxes are the same length. For a public terminal the size of the containers to be handled may not be known until the ship arrives.

(3) The use of two eight-hour shifts per day is assumed based on two factors. Unlike general cargo berths, the cargo transfer function is machine-oriented. This results in the need for fewer personnel in the operation of the terminal. Due to this mechanization, it is assumed that each berth can be worked on the basis of two full shifts per day. The second factor is the operation and maintenance requirements of the equipment. Although, theoretically, the cranes could be

operated on a third shift, such a level of activity would be impossible to maintain for any length of time. Operating a third shift would result in increased maintenance costs and down time for repairs, making it highly impractical, both economically and physically, on a sustained basis.

(4) To simplify the computations it is assumed that a linear relationship exists between a crane's transfer rate and the number of containers to be handled. Since both the berth service time and the crane capacity are constant, the total number of containers to moved by that crane is a constant. With this, it follows that the number of containers moved per vessel call determines the number of vessel trips to a particular facility. If the crane capacity is 10,000 containers per year it will take 10 vessel trips to move this cargo if each ship carries an average of 1,000 containers per trip. At 500 containers per vessel it would require a total of 20 vessel trips to handle the same amount of cargo.

c. Land Requirements. In addition to the area required for the actual storage of containers, including aisles, space must be provided for the apron or wharf working area, container freight station, maintenance garage, office and truck operations building, scales, access roadways, railroad tracks, and parking space along the loading and unloading docks of the container freight station. Based on the standards of the American Association of Port Authorities (AAPA), it was assumed that the gross land area requirement for a one-berth container terminal is two times the ground area needed for actual container placement. For terminals with two or more berths land requirements for

each additional berth are somewhat less in view of the fact that, generally, the additional space requirements for that second or third berth is primarily for the storage of containers, since major features such as freight consolidation and maintenance facilities are usually adequate to service the entire complex.

(1) Space requirements for containers were obtained for the various terminals. For facilities in which the actual number of parking slots in the container yard is not known, the following assumptions are made. For a 20-foot equivalent container, either chassis mounted or stacked one-high, one acre of land would provide storage for approximately 100 containers, including aisle space. For facilities using other length boxes, or stacking two and three high, this value was adjusted on a proportional basis.

(2) The purpose of using a block-stored system of container yard operation is for a more efficient utilization of the storage area. However, this efficient utilization of space results in a loss of operating efficiency due to decreased accessability of the containers. With containers stored on chassis the effort involved in accessing a particular container is minimal since all that is required is a tractor to transfer the box either to the dock area for loading on the ship, or delivery to the hinterland by way of the surface transportation network. For containers stacked two and three-high it is first necessary to use a straddle carrier, or transtainer, to remove the box from the stack and transport it to an awaiting chassis and tractor. A further complication is that the particular box involved may be on the bottom row. The increased handling in the container yard tends to increase the terminal's operating costs.

(3) With the straddle carrier operation, where the containers are stacked two-high, it is assumed that a system is used in which, 100 percent selectivity, with minimum redeployment and traveling, can be achieved if one space out of every three on the second tier is unoccupied. With this system any single container in the stack can then be withdrawn with a maximum of two short moves. This results in a storage capacity for a straddle carrier yard of 167 twenty-foot equivalent containers per acre.

(4) In the transtainer operation the containers are stacked three-high. In three-high stacking it is assumed that two out of every four positions in the third tier are unoccupied. With this arrangement any container can be removed with a maximum of three moves, resulting in the storage of 250 twenty-foot equivalent containers per acre.

(5) Within each container yard sufficient space must be allowed for the storage of empty containers. As previously discussed approximately 25 percent of the total container traffic through the Bay area ports are empty containers. In addition to the containers waiting to be filled with cargo there are always containers needing repairs that must be stored in the backup areas. Including the containers that are in the yard awaiting maintenance, it is assumed that 30 percent of the container positions would be occupied by empty containers.

(6) An analysis was made on the turnover of loaded containers in the backup area. It was found that as the containers were stacked higher, the turnover, in each of the container positons was less. In general, it is assumed that for a chassis operation, each container position experiences a turnover about every seven days, or some

fifty-two times per year. For the straddle carrier yard, a turnover of about once in ten days, or thirty-six times per year, and for a transtainer operation, every eighteen days or twenty times per year are assumed. Therefore, for the chassis mounted method of container storage, it is possible to handle approximately 3,600 loaded containers per acre annually.

(7) Container weight factor. To determine the amount of cargo carried in an average twenty-foot equivalent container, a survey was conducted of the major shipping lines operating in the study area, with four lines providing data. Since these lines are engaged in both foreign and domestic trade, it is assumed that they are representative of all the shipping companies calling at Bay Area ports. Actual container sizes were adjusted not only for length, but also for the height dimension to determine the number of twenty-foot equivalent containers (20'x8'x8') handled in 1974. It was found that for inbound cargo the density factor was 8.53 short tons, while that for outbound cargo averaged 9.58 short tons. With the inbound/outbound mix of cargo handled in 1974, an overall density of 9.22 short tons per twenty-foot equivalent container was calculated.

(8) Although this density factor could be expected to increase as shippers gain more experience in stuffing containers and achieve a more efficient utilization of space, this is expected to be offset somewhat as the percentage of total general cargo that is containerized increases. This occurs primarily due to the fact that historically, the density factor has been on the decline. This is due primarily to the fact that, generally, the commodities that were first containerized were those most susceptible to shipment in rectangular boxes (e.g. canned

goods). As additional commodities are containerized more light cargoes requiring large volumes will be in evidence, with the net effect of a slight reduction in the overall density factor.

(9) For the purposes of this study a container weight factor of 9.0 short tons per twenty-foot equivalent container is assumed.

d. LASH Terminals. Based on information provided by the LASH terminal operator, the typical LASH ship loads and discharges 49 lighters and 334 standard 20-ft. containers at each port of call. The lighters are loaded to 75 percent of their maximum capacity of 415 short tons. Information provided by port authorities indicates that the LASH operation will ultimately involve a six-ship fleet, with each ship making a call every 42 days.

e. Methodology. The capacity of each container terminal was analyzed in terms of two standards of measurement, "crane capacity" and "yard capacity". Based on the scheduling of ship arrivals, the average number of containers handled per call, and the assumed container transfer rate, the "crane capacity" standard estimates the total number of containers that the crane (or cranes) at each berth is physically capable of transferring to and from the container ship. This assumes that there are no constraints on the movement of containers through the port complex with respect to the available backup storage area or the land transportation facilities. For the LASH terminal the "crane capacity" is based on the expected LASH ship fleet and the anticipated cargo to be handled at each vessel call. The "yard capacity" standard was used to determine the capability of the existing backup storage facilities to handle the throughput of containerized cargo. For the LASH terminal

both the container storage yard and the Lighter Storage Basin were considered in determining the "yard capacity" measurement. A practical maximum capacity for each "standard" was calculated, with the lower of the two governing the handling capacity of the facility. During the course of the analysis, it was found that for most of the facilities the constraining factor was the land area used for the storage of containers.

38. SAMPLE CALCULATION

The following paragraphs present a sample calculation for a generalized container terminal. The methodology can be applied to each of the three types of container handling systems (i.e., chassis, straddle carrier, and transtainer), substituting the appropriate values for each of the criteria.

a. Crane Capacity. The transfer of a containership's cargo normally involves the use of two container cranes. If a total of 500 containers must be handled (400 loaded, 100 empty), it would take almost sixteen hours of berth time to service the ship, assuming a sustained practical rate of 16 container movements per hour for each of the two cranes. Based on the previously-discussed criteria of an allowable berth service time of four days out of every seven, it would then be theoretically possible to schedule the berth for four ships per week if two eight-hour shifts were worked each day. For a 50-week year the "crane capacity" of the facility would be approximately 82,000 loaded and 20,500 empty containers per year.

b. Yard Capacity. For a container berth that has 15 acres of land available for the container storage and the marshalling yard, and the containers are stacked two-high, it is possible to store at any one time approximately 2,500 twenty-foot equivalent containers (167 per acre). Assuming 30 percent of the containers are empty, this would leave 1,755 loaded containers. With a turnover in loaded containers of every ten days, this would give an annual throughput of 63,200 containers (20-ft. equivalents).

c. Berth Capacity. In comparing these two standards of measurement, it can be seen that the "yard capacity" would be the limiting constraint to the throughput of cargo. Using a container weight factor of 9.0 short tons per 20-ft. equivalent, this would result in an annual throughput of 570,000 short tons of cargo.

DRY BULK TERMINALS

39. INTRODUCTION

Bulk movement of goods is becoming an increasingly important part of the total tonnage of waterborne dry cargo traffic. Where the typical general cargo terminal must be equipped to handle many different kinds of goods, the bulk cargo terminal is generally designed for a single function, such as loading grain or unloading ore. The economic advantages of bulk handling are related to fast transfer rates; elimination of packaging, which increases the amount of cargo carried; and using larger bulk carriers. In many cases, the same firm controls the cargo at both ends of the waterborne shipment, as do the petroleum companies.

The majority of the bulk terminals are privately operated and are located on the processor's premises at one or both ends of the voyage. Commodities handled through these types of facilities include iron ore, cement, grains, and building materials.

40. TERMINAL CHARACTERISTICS

Bulk cargo terminal characteristics vary widely, being designed primarily for particular commodities. The major elements required for all dry bulk facilities are discussed below.

a. Storage Facilities. The storage requirement in any bulk cargo terminal must be adequate to meet the demands placed on the facility. The definition of what is adequate varies widely, and must be determined individually for each terminal. The minimum requirement is surge capacity to take up the slack between the rate of loading or unloading and the rate of transfer by either inland transportation or the use of the commodity in the processing facilities. As in all marine transportation operations, emphasis is placed on keeping the ship in port for as little time as possible. Therefore, as bulk carriers become larger and loading and unloading rates are increased, it is necessary to provide larger bulk storage facilities. Larger capacities are also required by seasonal restrictions on production. Agricultural products like grain and rice must be stored between harvests for year-round use. If the product is destined for water shipment, the shipping terminal is an efficient place to store it. The type of storage varies according to shipping requirements and the nature of the material. They may take the form of warehouses or silos for material requiring protection from the weather,

or open ground storage for nonperishable materials like crushed stone or iron ore.

b. Material-Handling Equipment. Lightweight powdered or fine granular materials, like cement and grain, can be transported pneumatically. However, most bulk materials are handled by conveyors or buckets and frequently by a combination of the two. There are numerous conveyor systems available for special functions. The belt conveyors are the most commonly used method of handling materials which are granular, powdered or lumpy. They can carry large quantities for long distances, horizontally or up and down slopes of 15 to 20^{o}. Bucket elevators, usually of a lower capacity than belts, are used to convey material vertically or up steep inclines. They are used for operations like filling silos, and, when mounted on a "marine leg," can be lowered into the ship's hold for unloading. There are many ships and barges which carry their own built-in unloading equipment. Ships carrying scrap metal usually carry cranes fitted with giant electromagnets for loading and discharging their cargo. Many sand and cement barges are self-equipped for cargo handling operations. Other types of material-handling systems include apron or pan conveyors, oscillating or vibrating conveyors, flight conveyors, and screw conveyors.

41. FACILITY OPERATION

The operation of a dry bulk facility is fairly straightforward. Depending on the type of handling system utilized, the cargo moves out of the ship's hold to the storage area, be it an open or closed area.

The material can be stock-piled in open storage by a traveling stacker having an inclined boom conveyor, which stores the material in piles along the side of the conveyor; or it may be elevated by incline conveyors to a distributing conveyor above the storage pile, which may be supported on a trestle or from the roof of the storage shed. Reclaiming the material may be done by means of a reclaiming conveyor in a tunnel underneath the storage, or it may be loaded into hoppers which feed a conveyor above ground. The conveyor from storage to shipside may be served by a stationary or traveling tower on the wharf, which may have a hinged or retractable boom conveyor supporting a chute at its end through which the material will drop into the hold of the ship.

42. CAPACITY CRITERIA

There are many factors to consider in determining the capacity of a dry bulk facility. Because many of these facilities are privately operated and are, for the most part, located near a processing plant, the demand for a particular dry bulk commodity, which is typically a raw material, is a function of the demand for the output of that plant. The use of larger bulk carriers usually results in the need for more storage facilities and equipment capable of handling the material at rapid rates. The criteria used in the evaluation of dry bulk facilities are as follows.

a. Those facilities, which are operated in conjunction with a processing plant and are used to receive raw materials utilized in the output of the installation, are constrained in terms of the physical

output of the plant itself. For example, if a particular plant is capable of processing 500,000 tons of ore annually, operating at full capacity, then this will be used as the practical maximum capacity of the marine facility associated with that processing plant.

b. The throughput of grain, rice, cement, and other types of dry bulk facilities was evaluated on the basis of the cargo transfer rates between the terminal and the vessel, and the terminal and the surface transportation facilities (i.e., railroads and trucks). The berth service time for the vessel is assumed to be sixteen hours per day, four days per week. That for the land transportation facilities is between ten and sixteen hours per day, five days per week, depending on the operating conditions at the individual facilities. Each facility was analyzed in terms of its historical use, and then, taking into consideration the physical limitation of presently installed cargo transfer equipment, estimates were made as to its practical maximum capacity.

LIQUID BULK TERMINALS

43. INTRODUCTION

In terms of the total tonnage the greater portion of liquid bulk traffic is made up of crude petroleum and its refined products. In June 1973 the West Coast Deepwater Port Facilities Study was published. This study was a joint effort of the Corps of Engineers's South Pacific Division in San Francisco, California and North Pacific Division in Portland, Oregon. The study dealt exclusively with potential deepwater

port facilities for the receipt and transshipment of crude petroleum and contained adequate data on existing crude petroleum facilities. For the purposes of this report all liquid bulk facilities will be evaluated with the exception of those involved in the receipt and shipment of crude petroleum. Included in the list of commodities shipped by liquid bulk facilities are refined and partially refined petroleum products, petro-chemicals, molasses, vegetable oils and fats, chemicals, and wines. Advantages gained in shipping by liquid bulk carriers are much the same as for the dry bulk cargo movements, primarily the elimination of barrels or other liquid containers, which increases the amount of cargo carried by tankers and reduces handling operations.

44. TERMINAL CHARACTERISTICS

The docking facilities for tanker and barge operations are relatively simple. The installation typically consists of a wharf or pier, with mooring appurtenances and equipment for handling the cargo hose which connects the ship's manifold to the pipelines on the dock. The pipelines are connected to storage tanks, which are generally located some distance from the dock. The more advanced bulk liquid carriers are capable of handling several different types of liquid and semi-liquid cargoes through parallel pipelines simultaneously. Since there is no requirement for warehouses or extensive cargo handling equipment, these docks are of a lighter construction than general cargo handling docks. In many cases the dock length is supplemented by dolphins to take the bow and stern lines.

45. CAPACITY CRITERIA

As in the case of the dry bulk terminals, most liquid bulk facilities are privately operated and serve as a means of receiving raw materials for processing into consumer products. Also much like the the dry bulk facility, the speed with which a vessel can unload and another take its place limits the throughput capacity of the terminal. The storage capacity is primarily a factor of the demand for the commodity and must be determined for each site on an individual basis. The following criteria were used to evaluate the cargo handling capacity of liquid bulk facilities in the study area.

a. Recent trends in the handling of petroleum products is to rely more and more on pipelines, as well as other modes of land transportation. Even though pipelines are heavily utilized for petroleum products, it is assumed that if the individual marine facility were physically capable of moving the products, the facility would be evaluated as to its cargo handling capacity. This is not to say that there will be a shift to this mode of transportation, only that the potential for marine transportation is there.

b. The procedure for evaluating marine facilities at refinery locations is as follows. For those docks which are physically capable of moving both the crude petroleum and the refined products, an estimate was made as to what portion of the refineries total output could be transported by ocean vessel. This estimate was used as the practical maximum capacity of the facility. This assumes that the output of the refinery is the major constraint on how much cargo will be available for shipment.

c. As with the refinery, the output of a processing plant serves as a limiting factor in determining the flow of commodities into and out of the system. This criteria is used for the other liquid bulk cargo operations in this category.

d. Marine facilities which serve as distribution terminals for petroleum products are primarily associated with the inland waterways barge traffic. For these facilities, the practical maximum capacity is indicated by the available storage capacity. Based on information developed from interviews with terminal operators it is assumed that there would be a turnover in the storage tanks of once per month or twelve times per year. If the demand for petroleum products were greater, and the supply available to meet that demand, then the capacity of the facility would, in turn, be greater.

EXISTING FACILITY CAPABILITY

46. INTRODUCTION

This section of the report provides for each port and major terminal facility in the San Francisco Bay Region the results of the analysis of the capability of existing marine facilities to handle waterborne commerce. It also includes those facilities that are under construction and those with construction permits that are expected to be operational by 1980. Waterborne facilities evaluated handle waterborne commerce in both the foreign and coastwise trade routes and the internal movement of cargo. Based on the assumptions and criteria previously discussed, a practical maximum capacity for each of the modes of cargo handling is estimated. All tonnage figures are presented on the basis of annual short tons (2,000 pounds) and represent an analysis of the facilities as they are currently being operated.

47. PORT FACILITIES AT SAN FRANCISCO

San Francisco is located just within the Golden Gate as shown in Plate 2. The principle waterfront facilities of the port extend from Aquatic Park on the north around to India Basin on the east side of the peninsula, a distance of nearly six and one-half miles.

48. San Francisco is primarily a general breakbulk cargo port, but does have specialized facilities for containerized and bulk cargo. It is the only passenger port in the region. Special terminals handle imported automobiles, bulk animal and vegetable oils, newsprint and grain. All deepwater piers are served by railroad spurs and accommodate vessels of 35-foot to 40-foot draft. There are a total of 47 berths at the Port of San Francisco equipped to engage in waterborne commerce trade, including both existing facilities and those presently under construction. Included in this total are 39 general cargo berths, six container berths, and the dry bulk grain terminal at Pier 90. There are two liquid bulk terminals, one located at Pier 84, which is the old Copra Terminal, and the second at a jointly used berth at Pier 92, which is primarily a general cargo terminal.

49. Most of San Francisco's general cargo trade is handled at finger piers on the northern waterfront. Container facilities are presently located at the Pier 80 complex, on the north side of Islais Creek; at the Pier 96 LASH (Lighter Aboard Ship) Terminal; and at the Mission

Rock Terminal (Pier 50). The LASH Terminal also includes an 11-acre water basin for handling and loading lighters. Currently under construction at Pier 94, located between the LASH Terminal and the Islais Creek Channel, is a container facility, scheduled for completion in 1976. A 10-acre facility for handling automobiles at Pier 70 was completed in 1974. An additional ten acres is available for future development.

50. Most of the internal cargo movement at the Port of San Francisco is handled at the Pier 96 LASH Terminal. Lighters are utilized for the receipt and shipment of cargo from inland ports. The cargo handling capacity of the facilities involved in the inland traffic is not easily distinguishable from those engaged in foreign and coastwise trade. The following tabulation indicates the practical maximum cargo handling capability for all marine facilities used in waterborne commerce trade.

	Practical Maximum Capacity (Short Tons Per Year)		
Method of Handling	Existing	Added By 1980	Total As of 1980
General Cargo	3,900,000	-	3,900,000
Container/LASH Cargo	1,800,000	600,000	2,400,000
Dry Bulk Cargo	720,000	-	720,000
Liquid Bulk Cargo 1/	80,000	-	80,000

1/ Excludes crude petroleum

51. PORT FACILITIES AT REDWOOD CITY

Redwood City Harbor is located on the west side of San Francisco Bay near its southern end as shown on Plate 3. The harbor, which consists of a channel and two turning basins, is situated within the confines of Redwood Creek, approximately 17 nautical miles south of the City of San Francisco. The Port area consists of 76 acres of improved property on the east side of the harbor and 106 acres of unimproved property on the west side, part of which is available for industrial purposes.

52. Facilities at Redwood City cater primarily to bulk cargoes. Historically, the chief products handled by the port have been cement, gypsum, salt, lumber, and petroleum products. General cargo facilities are also available. The controlling depth of the existing channel is -30 feet MLLW. The Ideal Cement Company has ceased operation at its two barge berths, and the Leslie Salt Company is phasing out its operation. Although the type of development to be accommodated at these sites has not yet been determined, the facilities were analyzed as to their capacity for the commodities previously handled. Rail tracks serving the waterfront facilities connect with the Southern Pacific Railroad Company. There are no rail yards in the port area.

53. There are a total of eight berths available. Five of these are used for foreign and coastwise traffic, the remainder as inland waterways terminals. General cargo requiring a protected storage area is handled at Wharf No. 1. Wharf No. 2 is used for bulk cement. Wharf No. 3 is an open wharf and is currently being renovated for use in the

export of steel scrap. Wharf No. 5 has provisions for the handling of both petroleum products and heavy lift cargoes such as logs and steel scrap. The Leslie Salt Wharf is used for both barge and ship traffic in the movement of bulk salt. A privately-operated facility is used for the receipt of sand and gravel by barges.

54. The practical maximum cargo handling capability for the facilities located at the Port of Redwood City are indicated in the following tabulation.

	Practical Maximum Capacity (Short Tons Per Year)	
Method of Handling	Existing Deepwater Port Facilities	Existing Inland Waterways Facilities
General Cargo	80,000	-
Container Cargo	-	-
Dry Bulk Cargo	2,200,000	2,200,000
Liquid Bulk Cargo 1/	600,000	-

1/ Excludes crude petroleum

55. PORT FACILITIES AT OAKLAND

Oakland is located on the eastern shore of San Francisco Bay, opposite San Francisco as shown on Plate 4. Waterfront facilities extend from the Outer Harbor, which is located immediately south of the San Francisco-Oakland Bay Bridge, to the Inner Harbor facility along the tidal canal connecting the Oakland-Alameda Estuary with San Leandro Bay. Total channel length in the Oakland-Alameda Estuary is eight and one-half miles from San Francisco Bay to San Leandro Bay.

56. Facility usage is primarily for foreign and coastwise trade, although some inland waterway commerce moves through the deepwater vessel facilities, particularly the container terminals. The facilities which were analyzed for the purposes of this report are located in four major terminal areas: Outer Harbor, Seventh Street Terminal, Middle Harbor, and the Inner Harbor.

a. Six berths are located in the Outer Harbor, with three additional berths to be in operation by 1980. Included are the container operation at Berths 8 and 9; the three berth breakbulk facility at the 14th Street Wharf and the breakbulk facility at Berth 10; and a three-berth container operation which will replace the unused GATX and Oil Pier facilities.

b. The Seventh Street Terminal features eight berths. Five of the berths have been specifically constructed to handle containers. Two berths are Roll-on Roll-off berth facilities. Berth 0, which is on the south side of Seventh Street, is not used for cargo transfer operations. The dock is used for the temporary storage of cargo from other terminals.

c. Four berths are available in the Middle Harbor for the handling of container cargo, and one berth at the Western Pacific Sugar Dock for the receipt of sugar for transfer into railroad cars.

d. Most of the Inner Harbor facilities are presently used for purposes other than waterborne commerce. With the completion of the 35-foot channel in mid-1975, some of the berths which are not being used for waterborne commerce will be reconditioned for waterborne commerce use. There are six berths in the Inner Harbor used for the movement of breakbulk and dry bulk commodities.

57. The following tabulation indicates the practical maximum capacity for all marine terminal facilities located at Oakland.

Method of Handling	Practical Maximum Capacity (Short Tons Per Year)			
	Deepwater Facilities			Existing Inland Waterway Facilities
	Existing	Added By 1980	Total As of 1980	
General Cargo	1,600,000	-	1,600,000	-
Container Cargo	5,200,000	1,500,000	6,700,000	-
Dry Bulk Cargo	500,000	-	500,000	120,000
Liquid Bulk Cargo 1/	-	-	-	-

1/ Excludes crude petroleum

58. PORT FACILITIES AT ALAMEDA

Port facilities in Alameda are located along the northern perimeter of the City of Alameda, an island across the Inner Harbor Channel from Oakland. Waterfront facilities extend from the Middle Harbor portions of the Oakland-Alameda Estuary to the Fruitvale Avenue Bridge crossing of the tidal channel. The facilities located at Alameda are publicly utilized, but privately operated. Included are four breakbulk berths and one berth each for containers and bulk liquid commodities. The location of these facilities is shown on Plate 4.

59. The following tabulation indicates the practical maximum cargo handling capability of all marine terminal facilities located at Alameda.

Method of Handling	Practical Maximum Capacity (Short Tons Per Year) Existing and as of 1980
General Cargo	420,000
Container Cargo	380,000
Dry Bulk Cargo	-
Liquid Bulk Cargo 1/	240,000

1/ Excludes crude petroleum

60. PORT FACILITIES AT RICHMOND

Richmond is located on the eastern side of San Francisco Bay, approximately nine miles northeast of the Golden Gate Bridge as shown on Plate 5. The Port area includes an Outer Harbor approximately five miles in length between Point San Pablo and Point Richmond; an Inner Harbor extending from Point Richmond to and around Point Potrero, and thence, to the inner end of Santa Fe Channel at Cutting Boulevard, a distance of 3.75 miles. The Outer Harbor faces natural deepwater in San Francisco Bay; the Inner Harbor has been dredged from deepwater in San Francisco Bay. The shore and channel between Point Richmond and Point Potrero are protected by a 10,000-foot training wall extending in a westerly direction from its anchorage on Brooks Island opposite the Santa Fe Channel.

61. The commodities handled at the Port of Richmond consist primarily of petroleum, dry bulk and other liquid bulk cargoes. Terminal No. 3 and Shipyard No. 3 currently provide automobile import/export facilities. Four berths at Shipyard No. 3 and one berth at the Parr-Richmond Bulk Commodity Wharf are currently used for the export of scrap metal. A variety of bulk liquids are handled through the Port of Richmond at Terminals No. 1, 3, and 4, including vegetable oil, molasses, and petroleum products. Four major oil companies have wharves, pipelines, and storage facilities for the receipt and shipment of petroleum, petroleum products, and petroleum chemicals. Approximately two-thirds of Richmond's total tonnage is shipped through the Standard Oil Company's Richmond Long Wharf, which is located in the Outer Harbor. One berth, owned by the National Gypsum Corporation, is used for the receipt of bulk gypsum rock.

62. The city of Richmond is now studying its port facilities with a view toward developing container facilities along the Inner Harbor channel. Terminal No. 3 will be modified for use as a container terminal. One berth is expected to be in operation by 1977.

63. The following tabulation indicates the practical maximum capacity of the terminal facilities located at Richmond, California. Since many of these facilities are used in both foreign and coastwise traffic as well as the inland waterways movement of cargo, no attempt was made at estimating the capacity for each type of trade.

Method of Handling	Practical Maximum Capacity (Short Tons Per Year) Existing	Added By 1980	Total As of 1980
General Cargo	60,000 1/	-	30,000 1/
Container Cargo	-	570,000	570,000
Dry Bulk Cargo	750,000	-	750,000
Liquid Bulk Cargo 2/	8,400,000	-	8,400,000

1/ That portion of Terminal No. 3 presently used for automobiles to be replaced by a container terminal.
2/ Excludes crude petroleum.

64. PORT FACILITIES ON SAN PABLO BAY, CARQUINEZ AND MARE ISLAND STRAITS

The southeastern shore of San Pablo Bay, the southern shore of Carquinez Strait, and both shores of Mare Island Strait are the areas considered in this section of the report, as shown on Plate 6. In these areas lie the communities of Pinole, El Sobrante, Hercules, Rodeo, Oleum, and Selby on San Pablo Bay; Benicia, Martinez, Port Costa, and Crockett, on Carquinez Strait; and Mare Island, Vallejo, and South Vallejo on Mare Island Strait.

65. With the exception of the Port of Benicia, all the facilities engaged in waterborne commerce serve specific industries. Five major oil companies, Gulf Oil at Hercules, Union Oil at Oleum, Shell Oil at Martinez, Exxon Oil at Benicia and Phillips Petroleum Company at Avon have wharves serving refineries. Although these facilities handle both crude oil and petroleum products, only the capacity for petroleum products was estimated. The Port of Benicia operates three berths which are used for the import of automobiles and the handling of petroleum coke, rutile and phosphate rock. Studies have been made to determine the feasibility of increasing the port's capability to handle a wide range of dry bulk commodities, including iron ore, chrome ore, woodchips, fertilizer and soda ash. Other major private wharves are operated by the California and Hawaiian Sugar Company at Crockett, and the Wade Corporation at Ozal. The Wade Corporation operates a petroleum terminal which is utilized as a backup storage facility for the U.S. Air Force bases and for other Federal fuel requirements in the general area. Fuel is imported by ship and delivered to the various installations by pipelines. Since the facility is not available for commercial use, no estimate of its cargo handling capability was made.

66. As previously indicated, pipelines and land transportation means are being heavily utilized for the distribution of petroleum products. Each of the refineries in the study area, however, was contacted as to the availability of existing facilities to handle petroleum products by

marine vessel. If the facilities were still operational, even though not being used for this purpose at the moment, an estimate of the annual throughput was made.

67. The estimated practical maximum capacity of existing facilities to handle both foreign and coastwise cargoes and inland waterways traffic is indicated in the following tabulation.

Method of Handling	Practical Maximum Capacity (Short Tons Per Year) Existing and as of 1980
General Cargo	120,000
Container Cargo	-
Dry Bulk Cargo	2,300,000
Liquid Bulk Cargo 1/	18,200,000

1/ Excludes crude petroleum

68. PORT FACILITIES ON THE WESTERN SACRAMENTO-SAN JOAQUIN DELTA

Waterfront facilities in the western delta area, as shown on Plate 7, are located on the left bank of New York Slough and the San Joaquin River at the vicinity of the cities of Pittsburg and Antioch, approximately 40 miles inland from the Golden Gate. New York Slough is a distributary of the San Joaquin River and connects the river to Suisun Bay. Port facilities in the Pittsburg-Antioch area are constructed adjacent to large industrial developments on the north shore of Contra Costa County.

69. Each of the facilities analyzed is used by ocean-going vessels and include Pacific Gas and Electric, the Diablo Service Corporation (Phillips Petroleum), U.S. Steel Corporation and Dow Chemical Company at Pittsburg, and the Kaiser Gypsum Company and Crown Zellerbach Company at Antioch. With the exception of the raw and finished steel products the commodities handled are either liquid or dry bulk materials, including paper pulp, gypsum rock, liquid chemicals, fuel oil, petroleum coke, sulfate and iron ore. The practical maximum cargo handling capability of these facilities is indicated on the following tabulation.

Method of Handling	Practical Maximum Capacity (Short Tons Per Year) Existing and as of 1980
General Cargo	600,000
Container Cargo	-
Dry Bulk Cargo	1,200,000
Liquid Bulk Cargo 1/	1,400,000

1/ Excludes crude petroleum.

70. PORT FACILITIES AT SACRAMENTO

The Port of Sacramento, shown on Plate 8, is located on the left bank of the Sacramento River, about 91 miles from the Golden Gate Bridge via the Sacramento Deepwater Ship Channel. Ocean-going vessels gain access to the Port of Sacramento from the ocean through San Francisco Bay, Carquinez Strait, and the Sacramento River Deep Water Ship Channel which terminates at a harbor and turning basin at West Sacramento.

71. The deep-draft ship channel, -30 feet MLLW, was formed by widening and deepening existing channels from the mouth of the Sacramento River upstream for 18 miles with the remaining 25 miles to the port accessible through an excavated canal. A 1.5-mile long, shallow-draft barge canal with navigation lock connects the deep-draft harbor with the Sacramento River. Shallow-draft vessels and barges navigate the river to Sacramento and upstream to Colusa. The channel between Sacramento and Colusa is approximately 85 miles in length. The Sacramento River Deep Water Ship Channel also is used for barge shipping because it provides a shorter route than the river, and because the greater depth and slack water provide better navigation conditions than in the Sacramento River.

72. The port has constructed general cargo, bulk woodchip, bulk rice, and bulk grain-handling facilities. Private interests own and operate barge facilities located along both banks of the river. These facilities are used for receipt of petroleum products and bulk cement. The six facilities serving ocean-going vessels have a 30-foot depth (MLLW). Piers 1 and 5 are used for shipment of bulk rice and bulk grain, respectively. Wharf 2 is used as a general breakbulk and automobile facility. Wharf 6 is an open dock and is used for heavy lift cargo such as logs and is presently utilized for loading and unloading containers from barges. The container barge service provided by the port operates between Sacramento and the Bay area ports. Wharf 7 and Pier 8 are utilized for general cargo and dry bulk cargoes, including fertilizer and woodchips. Pier 8 is an extension to Wharf 7 to facilitate maneuvering of bulk carriers during loading.

73. Six of the shallow-draft riverfront docks are for receipt of petroleum products; but only one is currently in use. Companies owning the other five docks now use the overland pipeline which traverses the area. All six facilities, however, are maintained for barge use should the pipeline be out of service.

74. The estimated practical maximum cargo handling capability of facilities at Sacramento, California is indicated below.

	Practical Maximum Capacity (Short Tons Per Year)	
Method of Handling	Existing Deepwater Facilities	Existing Inland Waterways Facilities
General Cargo	360,000	-
Container Cargo	-	120,000
Dry Bulk Cargo	2,400,000	380,000
Liquid Bulk Cargo 1/	-	640,000

1/ Excludes crude petroleum

75. PORT FACILITIES AT STOCKTON

The Port of Stockton, shown on Plate 9, is in the central part of the State, at the head of the Stockton Ship Channel. The distance from Golden Gate Bridge to the port is 75 nautical miles. From the Pacific Ocean, vessels reach the Port of Stockton via San Francisco Bay, Carquinez Strait, New York Slough, and the San Joaquin River-Stockton Ship Channel.

76. The port facilities at Stockton, California, handle cargo in both foreign and domestic trade. In addition to handling conventional general cargo, the port operates a LASH barge service between Stockton and the LASH Terminal at the Port of San Francisco. Other cargoes handled include molasses, bulk wine, scrap metal, bulk phosphates and fertilizers, grain, logs and other heavy lift cargo.

77. Berths 2 through 7 and 9 are used for general breakbulk cargo. Berth 8 is utilized for the export of metal scrap. Wharf 2 is an open dock and is used for both the storage of containers and the berthing of LASH lighters. Berths 10 and 11 handle most of the logs and heavy lift cargo. In addition, general cargo Wharf 4 is also used for the receipt of dry bulk materials, as are Berths 12 and 13. A grain elevator is available for the shipment of grain. Liquid bulk facilities for wine and molasses are also provided. Six facilities are equipped to receive petroleum products by water, including four shallow-draft terminals for the inland waterways traffic.

78. The estimated practical maximum cargo handling capability of facilities located at Stockton, California, are indicated below.

	Practical Maximum Capacity (Short Tons Per Year)	
Method of Handling	Existing Deepwater Facilities	Existing Inland Waterways Facilities
General Cargo	1,100,000	-
Container Cargo	-	120,000
Dry Bulk Cargo	4,000,000	-
Liquid Bulk Cargo 1/	1,000,000	840,000

1/ Excludes crude petroleum

79. SUMMARY

The following tabulation summarizes the capability of port facilities in the San Francisco Bay Region to handle waterborne commerce. The estimates listed under "inland waterways" represent the facilities used exclusively for that purpose. A portion of the facilities used for foreign and coastwise trade also handle some internal traffic.

80. Appendix B furnishes a summary of the cargo handling capability of the port facilities in the San Francisco Bay Region. Included in Table B-1 is a detailed listing of facility capability by specific commodity group for both liquid and dry bulk cargo facilities. Table B-2 has been provided to serve as an indicator of the variety of operational characteristics associated with container/LASH terminal operations. The "combination" operation includes terminals that combine two or more modes of container handling in the storage yard, including chassis-straddle, straddle-transtainer, and chassis-straddle-transtainer. Also included is the LASH terminal which handles both LASH lighters and conventional containers.

	Practical Maximum Capacity (1,000 Short Tons Per Year)			
	Deepwater Facilities			Existing
Method of Handling	Existing	Added By 1980	Total As of 1980	Inland Waterways Facilities
General Cargo	8,240	-	8,210 1/	-
Container/LASH Cargo	7,380	2,670	10,050	240
Dry Bulk Cargo	14,070	-	14,070	2,700
Liquid Bulk Cargo 2/	29,920	-	29,920	1,480

1/ "Total" reflects the modernization at the Port of Richmond of one general cargo berth for use in handling containerized cargo.

2/ Excludes crude petroleum.

81. DISCUSSION

Care must be exercised in using the estimates of practical maximum capacity presented in this report. The cargo handling capability of a port's physical assets (i.e., number of berths and cranes, backup storage area, etc.) is only one set of factors that influence the operation of a marine terminal. It is not always easy to predict the demands which might be made on a particular berthing facility. The trade route serviced by a berth is influential in this aspect. Each trade route is more or less unique in terms of the types of commodities which are handled. The criteria that were developed for estimating port facility capabilities are based on an analysis of the commodity movements in the study area. Since it is impossible to predict with any degree of precision the types of commodities that any single berth might handle, particularly breakbulk facilities, the criteria were chosen such that they represent average values for the wide range of commodities that can be handled by each of the modes of cargo handling facilities. The operation of any one terminal may differ substantially from another. Cotton, which is shipped in bales, is one case in which volume considerations with respect to storage requirements in the transit shed and in the ship's cargo hold tend to over-shadow the weight constraints. That is, 40 cubic feet (a measured ton) of that commodity weighs less than 2,000 pounds (a weight ton). Since the criteria developed for transit shed storage capability are based on a trade-off between available storage volume and the total tonnage that can be structurally supported, the capacity of a facility servicing volume oriented commodities could be reached sooner than that estimated by the criteria outlined in this report.

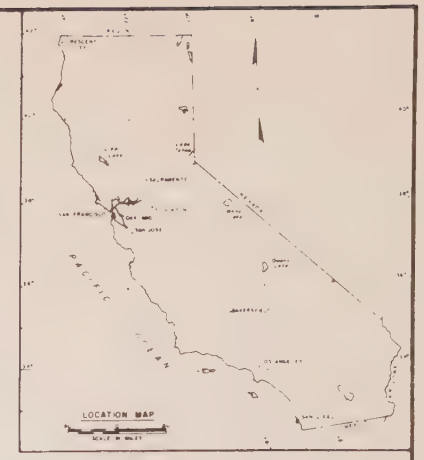
82. In evaluating the capacity of existing container facilities in the San Francisco Bay Region, it was found that, in most cases, for terminals devoted exclusively to a container operation, the constraining factor was the land area used for the storage of containers. Based on the criteria discussed in this report, there is an existing crane capacity of approximately 13.7 million tons of container cargo annually, while the capability of the supporting land area is about 10.8 million tons. Most of the land adjacent to existing container terminals is not suitable or not available for various economic and social reasons for expansion of present container yards. In addition, as the land area per berth increases, it acts as a deterrent to fast handling and increases throughput costs.

83. For the purposes of this report present methods of facility operation at individual sites are assumed to continue to be used. Each shipping line offers a variety of services to attract business. To a great extent these services are a determining factor in the operation of the facilities. This is particularly true for container terminals, where the emphasis is on speed, dependability of delivery and low transportation costs. Although it may be possible to increase the throughput of a facility by changing its mode of operation (e.g., container stacking versus container chassis), there is, at present, no adequate means to assess the impact that this may have on the shipping line and its ability to compete in the market place.

84. Most of the major ports in the study area are municipally-owned and are administered by independent port commissions. The port facilities themselves are operated either by the steamship lines or by private terminal operators. As such, the role of the port authorities is essentially one of a landlord, providing the facilities to suit the individual tenants' needs. The tenants' needs depend on the services provided to their customers. Because of the wide variety of services offered by the shipping industry, it is not possible to provide a single type facility that will meet everyone's needs. Within each public port a certain number of berths are used as public berthing facilities, with access on a first-come, first-serve basis. The remainder of the berths are leased out to various companies for their exclusive use. This is done with the expressed purpose of having berthing facilities at all times such that the leaseholder's ship will not have to wait for a berth to become available. Facilities operated in this manner tend to have a higher utilization factor than publicly accessible berthing. This brings to light the question of operational capacity versus competitive capacity. At what point is it economically advantageous to a company to lease a berth, or berths, rather than rely on public berthing facilities? This is a very difficult question to answer and is beyond the scope of this report. However, the concept of competitive capacity should be considered in determining the need for future port facilities and, will be addressed in the assessment studies.

85. Thus, due to these operating arrangements of preferential berthing, in which the larger shipping lines have exclusive use of a terminal complex, it is easy to see that an excess capacity at one berth is not always available to handle cargo destined for berths being fully utilized.

86. The findings of this report will be integrated with the results of the report on Commodity Flow Projections to determine whether there is a shortage or overage of port facilities to handle future waterborne commerce in the San Francisco Bay Region.



SONOMA
NAPA
YOLO
SOLANO
SACRAMENTO
MARIN
CONTRA COSTA
SAN JOAQUIN
ALAMEDA
SAN MATEO
SANTA CLARA
SAN FRANCISCO
PACIFIC OCEAN
SAN PABLO BAY
SUISUN BAY
SUISUN MARSH
SACRAMENTO RIVER
MAIN SHIP CHANNEL
SACRAMENTO CITY EXECUTIVE AIRPORT
GOLDEN GATE BRIDGE
SAN FRANCISCO OAKLAND BAY BRIDGE
CARQUINEZ BRIDGE
BENICIA MARTINEZ BRIDGE
RICHMOND SAN RAFAEL BRIDGE
SAN MATEO BRIDGE
DUMBARTON BRIDGE
SAN FRANCISCO INTERNATIONAL AIRPORT
SANTA ROSA
NAPA
FAIRFIELD
MARTINEZ
CHIPPS ISLAND
ANTIOCH
STOCKTON
TRACY
VERNALIS
SAN JOSE
REDWOOD CITY
OAKLAND
SAN RAFAEL
WOODLAND
LAKE BERRYESSA
FOLSOM RES
NEW HOGAN RES
RUSSIAN RIVER
NAPA RIVER
PETALUMA RIVER
AMERICAN RIVER
MOKELUMNE RIVER
CALAVERAS RIVER
GUADALUPE RIVER
ALAMEDA CREEK
CORTE MADERA CREEK
SAN FRANCISCO BAY
TOMALES BAY
DRAKES BAY
SCALE IN MILES

LEGEND

MAJOR COMMERCIAL AIRPORTS

PUBLIC PORT AREAS

SAN FRANCISCO BAY AREA IN-DEPTH STUDY CALIFORNIA

PORT FACILITY CAPABILITY

SAN FRANCISCO BAY REGION

US ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS

DRAWN
TRACED
CHECKED
TO ACCOMPANY REPORT
DATED
FILE NO
1-1-191

PLATE 1

LEGEND

1. GENERAL CARGO TERMINAL
2. CONTAINER TERMINAL
3. DRY BULK TERMINAL
4. LIQUID BULK TERMINAL
5. LASH TERMINAL

CUSTOM HOUSE

GENERAL CARGO TERMINALS - FOREIGN TRADE

GENERAL CARGO TERMINALS - COASTWISE & INTERCOASTAL TRADE

GRAIN ELEVATOR

GRAIN HANDLING

NOTES:

1. FACILITIES NOT INDICATED SO ARE PRESENTLY USED FOR OTHER THAN CARGO HANDLING PURPOSES

SAN FRANCISCO BAY AREA IN DEPTH STUDY CALIFORNIA

PORT FACILITY CAPABILITY

PORT FACILITIES AT SAN FRANCISCO, CALIFORNIA

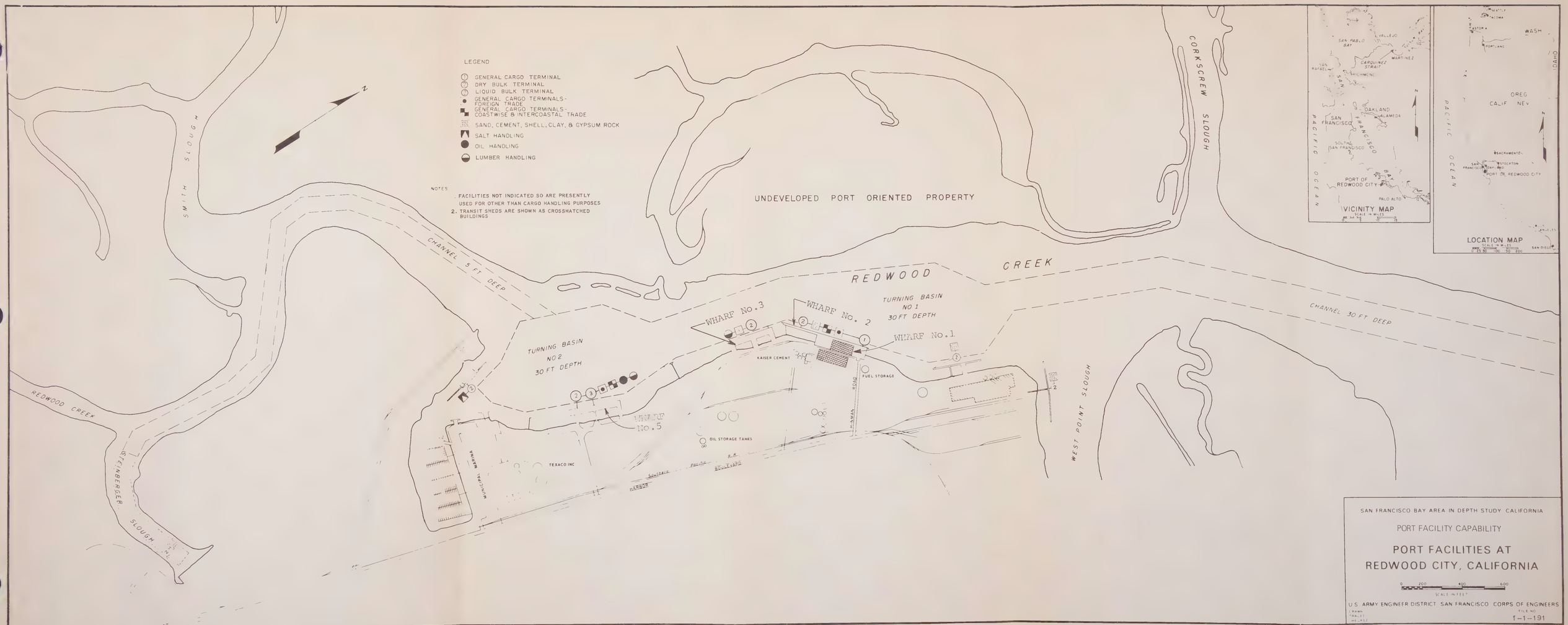
SCALE IN FEET

U.S. ARMY ENGINEER DISTRICT SAN FRANCISCO CORPS OF ENGINEERS

DRAWN
TRACED
CHECKED

FILE NO
1-1-191

PLATE 2



SAN FRANCISCO BAY AREA IN DEPTH STUDY CALIFORNIA

PORT FACILITY CAPABILITY

PORT FACILITIES AT REDWOOD CITY, CALIFORNIA

SCALE IN FEET

U.S. ARMY ENGINEER DISTRICT SAN FRANCISCO CORPS OF ENGINEERS

DRAWN
TRACED
REVISED

FILE NO. 1-1-191

PLATE 3

OAKLAND
SAN FRANCISCO BAY
OAKLAND ARMY TERMINAL
OAKLAND OUTER HARBOR
INNER HARBOR
MIDDLE HARBOR
SEVENTH STREET TERMINAL
NAVAL SUPPLY CENTER
BROOKLYN BASIN
GOVERNMENT ISLAND
ALAMEDA
SAN LEANDRO BAY
BAY FARM ISLAND
OAKLAND AIRPORT
CHANNEL DEPTH - 35 FT
LEGEND
1 GENERAL CARGO TERMINAL
2 CONTAINER TERMINAL
3 DRY BULK TERMINAL
4 LIQUID BULK TERMINAL
5 COMBINED GENERAL - CONTAINER
CUSTOM HOUSE
GENERAL CARGO TERMINALS - FOREIGN TRADE
GENERAL CARGO TERMINALS - COASTWISE & INTERCOASTAL TRADE
TERMINAL OF INLAND CARRIER
BULK FREIGHT - MISCELLANEOUS
STORAGE WAREHOUSES
COLD STORAGE WAREHOUSES
OIL HANDLING
SUGAR HANDLING
LUMBER HANDLING
GRAIN HANDLING
GRAIN ELEVATORS
CHEMICAL HANDLING
PETROCHEMICAL HANDLING
NOTES:
1. FACILITIES NOT INDICATED SO ARE PRESENTLY USED FOR OTHER THAN CARGO HANDLING PURPOSES.
SAN FRANCISCO BAY AREA IN DEPTH STUDY CALIFORNIA
PORT FACILITY CAPABILITY
PORT FACILITIES AT OAKLAND AND ALAMEDA, CALIF.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
1-1-191
PLATE 4

SAN PABLO BAY
CASTRO CREEK
SAN FRANCISCO BAY
PT SAN PABLO TERMINAL NO. 4
PT ORIENT
WINEHAVEN
THE BROTHERS
MOLATE PT
CASTRO PT
CASTRO ROCKS
RED ROCK
RICHMOND-SAN RAFAEL BRIDGE
STATE HWY NO 17
APPROACH AREA 35 FT DEPTH
CONNECTING CHANNEL 35 FT DEPTH
ENTRANCE CHANNEL 35 FT DEPTH
INNER HARBOR CHANNEL
SANTA FE CHANNEL
INNER HARBOR BASIN
RICHMOND INNER HARBOR
PT RICHMOND
FERRY POINT
BROOKS I
35 FT DEPTH
30 FT
1 GENERAL CARGO TERMINAL
2 CONTAINER TERMINAL
3 DRY BULK TERMINAL
4 LIQUID BULK TERMINAL
DRY STORAGE WAREHOUSES
BULK HANDLING - DRY
MARINE RAILWAYS
DRYDOCKS
OIL HANDLING
MOLASSES HANDLING
SHIPBUILDING PLANTS
PETROCHEMICAL HANDLING
MARINE REPAIR PLANTS
VEGETABLE OIL HANDLING
CHEMICAL HANDLING
GENERAL CARGO TERMINALS - FOREIGN TRADE
GENERAL CARGO TERMINALS - DOMESTIC TRADE
NOTES
1. FACILITIES NOT INDICATED ARE PRESENTLY USED FOR OTHER THAN CARGO HANDLING PURPOSES.
2. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
SAN FRANCISCO BAY AREA IN DEPTH STUDY CALIFORNIA
PORT FACILITY CAPABILITY
PORT FACILITIES AT RICHMOND, CALIFORNIA
SCALE IN FEET
U.S. ARMY ENGINEER DISTRICT SAN FRANCISCO CORPS OF ENGINEERS
DRAWN
TRACED
CHECKED
FILE NO 1-1-191

PLATE 5

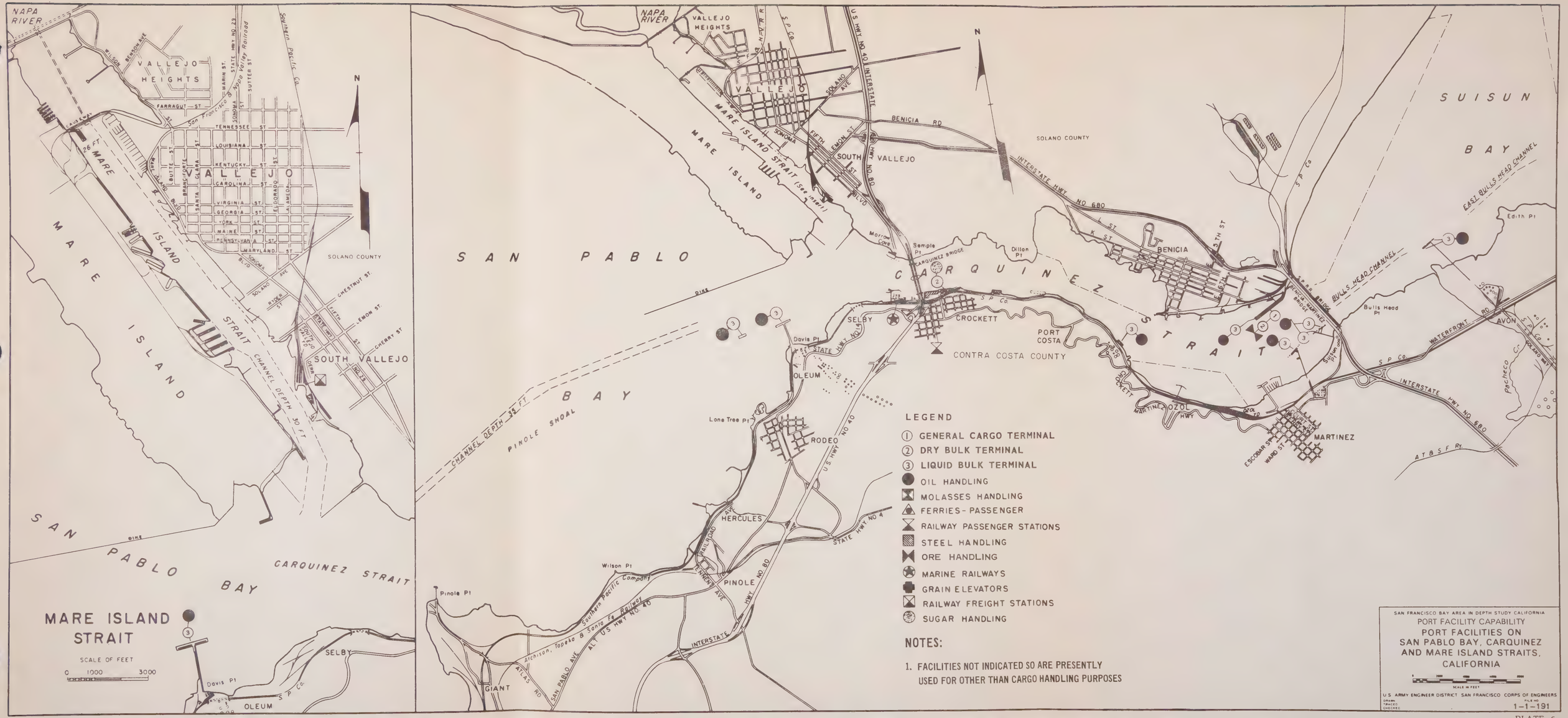

NAPA RIVER
VALLEJO HEIGHTS
VALLEJO
SOUTH VALLEJO
MARE ISLAND
MARE ISLAND STRAIT
SCALE OF FEET
0 1000 3000
SOLANO COUNTY
SAN PABLO BAY
CARQUINEZ STRAIT
CHANNEL DEPTH 35 FT
CHANNEL DEPTH 30 FT
PINOLE SHOAL
SUISUN BAY
EAST BULLS HEAD CHANNEL
BULLS HEAD CHANNEL
CONTRA COSTA COUNTY
BENICIA
CROCKETT
PORT COSTA
SELBY
OLEUM
RODEO
HERCULES
PINOLE
MARTINEZ
AVON
Edith Pt
Bulls Head Pt
Sample Pt
Dillon Pt
Davis Pt
Lone Tree Pt
Wilson Pt
Pinole Pt
GIANT
INTERSTATE HWY NO 680
U S HWY NO 40 INTERSTATE
STATE HWY NO 4
WATERFRONT RD
INTERSTATE HWY NO 680
A T & S F Ry
Southern Pacific Company
Atchison, Topeka & Santa Fe Railway
LEGEND
1 GENERAL CARGO TERMINAL
2 DRY BULK TERMINAL
3 LIQUID BULK TERMINAL
OIL HANDLING
MOLASSES HANDLING
FERRIES - PASSENGER
RAILWAY PASSENGER STATIONS
STEEL HANDLING
ORE HANDLING
MARINE RAILWAYS
GRAIN ELEVATORS
RAILWAY FREIGHT STATIONS
SUGAR HANDLING
NOTES:
1. FACILITIES NOT INDICATED SO ARE PRESENTLY USED FOR OTHER THAN CARGO HANDLING PURPOSES
SAN FRANCISCO BAY AREA IN DEPTH STUDY CALIFORNIA
PORT FACILITY CAPABILITY
PORT FACILITIES ON SAN PABLO BAY, CARQUINEZ AND MARE ISLAND STRAITS, CALIFORNIA
SCALE IN FEET
U S ARMY ENGINEER DISTRICT SAN FRANCISCO CORPS OF ENGINEERS
FILE NO 1-1-191

PLATE 6

LEGEND

① GENERAL CARGO TERMINAL
② DRY BULK TERMINAL
③ LIQUID BULK TERMINAL

NOTES:

1. FACILITIES NOT INDICATED SO ARE PRESENTLY USED FOR OTHER THAN CARGO HANDLING PURPOSES.

SAN FRANCISCO BAY AREA IN-DEPTH STUDY CALIFORNIA

PORT FACILITY CAPABILITY

PORT FACILITIES ON THE WESTERN SACRAMENTO-SAN JOAQUIN DELTA

SCALE IN MILES

IN SHEETS SHEET NO

U S ARMY ENGINEER DISTRICT SAN FRANCISCO, CORPS OF ENGINEERS

DRAWN TRACED CHECKED

FILE NO 1-1-191

PLATE 7

SACRAMENTO RIVER
BRODERICK
BRYTE
WEST SACRAMENTO
SACRAMENTO
MILLER PARK
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
LAKE WASHINGTON
LEGEND
① GENERAL CARGO TERMINAL
② CONTAINER BARGE TERMINAL
③ DRY BULK TERMINAL
④ LIQUID BULK TERMINAL
NOTES:
1. FACILITIES NOT INDICATED SO ARE PRESENTLY USED FOR OTHER THAN CARGO HANDLING PURPOSES.
SAN FRANCISCO BAY AREA IN DEPTH STUDY CALIFORNIA
PORT FACILITY CAPABILITY
PORT FACILITIES AT SACRAMENTO, CALIF
U.S. ARMY ENGINEER DISTRICT SAN FRANCISCO CORPS OF ENGINEERS
1-1-191,

PLATE 8

LEGEND

- ① GENERAL CARGO TERMINAL
- ② CONTAINER BARGE TERMINAL
- ③ DRY BULK TERMINAL
- ④ LIQUID BULK TERMINAL
- GENERAL CARGO TERMINALS - FOREIGN TRADE
- GENERAL CARGO TERMINALS - DOMESTIC TRADE
- BULK HANDLING - DRY & LIQUID COMMODITIES
- STORAGE WAREHOUSES
- COLD STORAGE WAREHOUSES
- SHIPBUILDING PLANTS
- COTTON COMPRESS
- MOLASSES HANDLING
- GRAIN HANDLING
- OIL HANDLING
- PILING & LOGS HANDLING
- ORE HANDLING
- GRAIN STORAGE AND GRAIN ELEVATORS

NOTES:

FACILITIES NOT SO INDICATED ARE PRESENTLY USED FOR OTHER THAN CARGO HANDLING PURPOSES

SAN FRANCISCO BAY AREA IN-DEPTH STUDY CALIFORNIA

PORT FACILITY CAPABILITY

PORT FACILITIES AT STOCKTON, CALIF.

0 400 800 1200 1600

SCALE IN FEET

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS

DRAWN
TRACED
CHECKED

FILE NO. 1-1-191

PLATE 9

APPENDIX-A

PORT CAPACITY CRITERIA

APPENDIX A
PORT CAPACITY CRITERIA
ASSUMPTIONS

GENERAL

1. It is assumed that as the amount of cargo through each facility increases, the terminal will be operated in such a manner as to take full advantage of the physical components of the system.

2. Each berth is evaluated individually and the assumptions are adjusted to reflect the on-site conditions.

3. Manpower requirements are considered to be adequate to meet any demands which might be placed on them. It is assumed that with sufficient lead time the labor unions would be able to provide the personnel necessary to operate each port facility in the study area.

4. With the exception of the grain terminals, it is assumed that the rail and truck facilities in the study area are adequate to maintain the flow of cargo through the port complexes, and thus are not evaulated in this report. The land-side transportation system relative to the grain terminals was considered in determining berth capacity.

5. To simplify the computations it is assumed that a linear relationship exists between the cargo transfer rate and the amount of cargo to be handled. This applies to both the use of longshoremen for general cargo and cranes for containers. Since both the berth service time and the transfer rate are constants, the total amount of cargo that can be moved is a constant. For example, if the crane capacity of a particular berth is 10,000 containers per year, it would take 10 vessel trips to

move this amount of cargo, if each ship carries an average of 1,000 containers per trip. At 500 containers per vessel it would require a total of 20 vessel trips to transport the same amount of cargo.

GENERAL CARGO TERMINALS

1. SHIP CAPACITY.

a. Ship load. The average breakbulk ship handles 1,500 short tons (both on and off) per call, with 2,000 short tons for Roll-on and Roll-off vessels and between 10,000 and 18,000 short tons of cargo for ships transporting heavy-lift cargo, such as logs or lumber.

b. Scheduling. Each berth is worked on the basis of 1-1/2 shifts per day (12 hours) and is scheduled for cargo transfer operations four days out of every seven, or a total of 48 hours (4 days x 12 hrs/day) each week.

c. Cargo transfer rate. For a general breakbulk ship, based on a three-gang crew, the cargo transfer rate is 540 tons/day (15 tons per hour per gang, 12-hr day). For steel, autos, and heavy-lift cargo, the rate is 900 tons/day (25 tons per hour per gang, 12-hr day).

2. STORAGE CAPACITY.

a. Floor utilization. It is assumed that 50 percent of the gross floor area is used for the actual placement of cargo. The remaining 50 percent is utilized for aisles, equipment storage, offices, and the area required to efficiently handle the movement of cargo from ship-to-shore and vice-versa.

b. Transit shed storage. Cargo in a transit shed can be stacked up to a height of 15 feet. To compensate for the mix of weight and volume oriented cargo it is assumed that the actual floor loading due

to the placement of cargo is equal to 50 percent of its rated structural capacity. For a transit shed floor rated at 500 p.s.f., a cargo density of up to 0.125 t.s.f. could be accommodated.

c. Open storage. Area requirements for the storage of heavy-lift cargoes such as automobiles, logs, machinery are pretty much site specific and depend on the nature of the cargo being handled. In many cases these open areas are far removed from the waterfront location and situated in the back up areas of the port. It is assumed that log storage requires an acre for each 4,000 short tons, while automobiles store at 150 per acre at 2,000 pounds per auto.

d. Cargo turnover. The time the cargo occupies the storage space affects the capacity of the facility. For transit shed storage it is assumed that there is a turnover in cargo every 10 days or some 36 times per year. For automobiles, where more time is required for inspection for theft and damage incurred during transit, a turnover of twenty days, or eighteen times per year, is used. The turnover rates for logs and lumber are around six to eight times a year and not as closely related to the available storage area. This is due to the availablity and demand characteristics of the commodity.

CONTAINER CARGO TERMINALS

1. CRANE CAPACITY.

a. Ship load. Due to the nature of the container traffic through San Francisco Bay ports, approximately 25 percent of the traffic consists of empty containers. It is assumed that the average container ship transfers 500 containers at each vessel call, of which 400 are loaded containers and 100 are empties.

b. Scheduling. Each berth is worked on the basis of two eight-hour shifts per day and is scheduled for cargo moving operations four days out of every seven, or a total of 64 hours (4 days x 16 hrs/day) each week. This figure represents the actual crane time available for the working of the ships.

c. Crane capacity. It is assumed that a full container crane can operate at a sustained rate of from 16 to 21 container movements per hour.

(1) Seventeen containers per hour is assumed for those multiple-user terminals operated by a steamship line, while the public container terminal cranes are rated at 16 containers per hour.

(2) For the single-user terminal operated by a steamship line 21 containters per hour is used. It is assumed that chassis-mounted container cranes operate at 15 container movements per hour.

2. STORAGE CAPACITY.

a. Storage requirements. For those terminals in which the actual container storage area is not known, it is assumed that the terminal's gross area is twice the actual container placement area needed. The additional area is required for offices, CFS's, parking lots, road or railroad access, etc.

(1) For these terminals it is assumed that 100 twenty-foot equivalent containers can be stored (1-high) on one acre of land.

(2) It is assumed that 30 percent of the containers in the storage area are empty, awaiting cargo or maintenance.

b. Container Stacking.

(1) Straddle carrier (2-high): One space out of every three on the second tier is unoccupied

2-high = 1-high + 67%

(2) Transtainer (3-high): Two out of every four spaces on the third tier is unoccupied

3-high = 1-high + 150%

c. Container storage turnover.

(1) Chassis = 52 times/yr. (every 7 days)

(2) Straddle (2-high) = 36 times/yr. (every 10 days)

(3) Transtainer (3-high) = 20 times/yr. (every 18 days)

d. Container weight factor. Short tons per twenty-foot equivalent container equal to 9.0.

3. LASH TERMINALS.

The typical LASH ship loads and discharges 49' lighters and 334 standard 20-ft. containers at each port of call. It is assumed that the lighters are loaded to 75 percent of their maximum capacity of 415 short tons. It is assumed that ultimately, the LASH fleet will consist of six vessels, with each ship making a call every 42 days.

BULK CARGO TERMINALS

1. DRY BULK TERMINALS.

a. Those facilities which are operated in conjunction with a processing plant, and are used for the receipt of raw materials, are

usually constrained in terms of the annual tonnage handled by the plant - a factor determined by the output of the plant's production line.

b. Throughput of grain, rice and other types of elevator operations are evaluated in terms of three constraints; the vessel capacity to move cargo across the dock; the storage capacity of the facility; and the capacity of the facility to handle the intermodal transfer of the cargo from the surface transportation element. The berth service time for the vessel is assumed to be sixteen hours per day, four days per week. The time for the land transportation facilities is between ten and sixteen hours per day, five days per week, depending on the operating conditions at the individual facilities.

2. LIQUID BULK TERMINALS.

a. As in the case of the dry bulk terminals, most liquid bulk facilities are privately operated and serve as a means of receiving raw materials for processing into consumer products. Also much like the dry bulk facility, the speed with which a vessel can unload and another take its place limits the throughput capacity of the terminal. The storage capacity is primarily a factor of the demand for the commodity and must be determined for each site on an individual basis.

b. Dock facilities at refineries are rated for shipment of petroleum products providing that the marine terminal facilities are physically capable of handling the cargo - even though pipelines and other land transportation facilities are now being used to handle some of this cargo.

c. Marine facilities which serve as distribution terminals for petroleum products are primarily associated with the inland waterways

barge traffic. For these facilities, the practical maximum capacity is indicated by the available storage capacity. For the purposes of this study it is assumed that there would be a turnover in the storage tanks of once per month or twelve times per year. If the demand for petroleum products were greater, and the supply available to meet that demand, then the capacity of the facility would, in turn, be greater.

APPENDIX-B

TABLES

TABLE B-1
PRACTICAL MAXIMUM CAPACITY
FACILITIES AS OF 1980
(Thousands of short tons per year)

METHOD OF HANDLING (Commodity Group)	SAN FRANCISCO BAY AREA	DELTA AREA	TOTAL, SAN FRANCISCO BAY REGION
Breakbulk			
General	5,500	1,180	6,680
Heavy-lift 1/	650	880	1,530
Subtotal	6,150	2,060	8,210
Container/LASH	10,050	2/	10,050
Dry Bulk			
Farm products	720	1,280	2,000
Metallic ores	650	2,800	3,450
Coal and non-metallic minerals	1,500	1,100	2,600
Food	1,000	250	1,250
Lumber	-	1,000	1,000
Stone, clay	500	-	500
Primary metals	460	520	980
Waste, scrap	1,640	650	2,290
Subtotal	6,470	7,600	14,070
Liquid Bulk			
Food	820	380	1,200
Chemicals	-	200	200
Petroleum products	26,700	1,820	28,520
Subtotal	27,520	2,400	29,920
TOTAL	50,190	12,060	62,250

1/ Includes lumber, logs, and transportation equipment.
2/ Container barge and LASH vessel traffic, to and from the Delta, is by definition an internal movement and is therefore not included in this table.

TABLE B-2

CONTAINER/LASH TERMINALS
FACILITIES AS OF 1980

MARSHALLING YARD OPERATION	NO. BERTHS	NO. CRANES	CONTAINER YARD(acres)	CAPACITY (1,000 TEU/YEAR) 1/ CRANE	YARD	FACILITY 2/	PRACTICAL MAXIMUM CAPACITY (1,000 SHORT TONS/YEAR) 3/
Chassis	6	8	75.0	663	343	343	3,090
Straddle Carrier	8	11	98.7	480	426	414	3,770
Combination 4/	8	9	102.0 5/	376 6/	430 6/	353 6/	3,190
TOTAL	22	28	275.7	1,519	1,199	1,110	10,050

1/ TEU = twenty-foot equivalent units (20'x8'x8').
2/ The "facility" capacity is taken as lower of the "crane capacity and the "yard" capacity, whichever was the constraining factor of the terminal complex.
3/ Based on 9.0 short tons per TEU.
4/ Includes facilities that use more than one mode of container storage in the back-up area. Also includes LASH/Terminal.
5/ Includes the lighter storage basin.
6/ Adjusted for lighters.

APPENDIX-C

BIBLIOGRAPHY

APPENDIX C

BIBLIOGRAPHY

American Association of Port Authorities, Standing Committee IV, Construction and Maintenance, Port Planning Design and Construction, 1973.

Boyer, Walter C., American Society of Civil Engineers Meeting Preprint 1571, Containerization - A System Still Evolving, January 1972.

De F. Quinn, Alonzo, Design and Construction of Ports and Marine Structures, 2nd edition, McGraw-Hill Book Co., 1972.

Department of Commerce, Maritime Administration, Inventory of American Intermodal Equipment, 1973.

Fratar, Thomas J., Journal of Waterways and Harbor Division, American Society of Civil Engineers, "Prediction of Maximum Practical Berth Occupancy," June 1960.

Hoffmaster, Bob N. and Charles L. Vickers, Journal of Waterways and Harbor Division, American Society of Civil Engineers, "Port Structures in Long Beach Harbor".

Plumlee, Carl H. Journal of Waterways and Harbor Division, American Society of Civil Engineers, "Optimum Size Seaport", August 1966.

Manalystics, Inc., The Impact of Containerization on the United States Transportation System, prepared for the U.S. Department of Commerce, Maritime Administration, February 1972.

Maritime Cargo Transportation Conference, National Academy of Sciences, National Research Council, San Francisco Port Study, 1964.

Stanford Research Institute, Marine Terminal Requirements in California For 1975, prepared for California State Office of Planning, November 1965.

Tozzoli, Anthony J., Journal of Waterways, Harbors and Coastal Engineering Division, American Society of Civil Engineers," Containerization and its Impact on Port Development," August 1972.

U.S. Army Corps of Engineers, San Francisco District, Project and Index Maps, River and Harbor and Flood Control, June 1975.

U.S. Army Corps of Engineers, San Francisco District, San Francisco Bay Area In-Depth Study, Vessels and Port Facilities Analysis, "Channels, Ports and Related Facilities Inventory," June 1973.

U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part 4, 1969, 1970, 1971, 1972, 1973.

77 00524

U.C. BERKELEY LIBRARIES
C123317776

INSTITUTE OF GOVERNMENTAL STUDIES LIBRARY
109 PHILOSOPHY HALL
UNIVERSITY OF CALIFORNIA
BERKELEY, CA 94720